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Final Report

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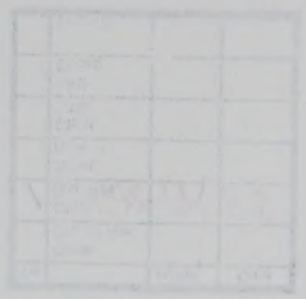

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Fishes and Their Relationships to Environments in Selected Coastal Streams, Douglas and Coos Counties, Oregon.

Introduction

The coastal streams of western Oregon have been demonstrated (Chapman 1965; Everest 1973; Giger 1972; Hall and Lantz 1968) as important rearing areas for large populations of juvenile salmon and trout considered to be of high value to the people of Oregon and the Pacific Northwest. These streams, furthermore, contain various single or multi-species populations of non-game fishes. Most of these non-game fishes are considered by the public and resource agencies to be of low value, often being accused as predators of juvenile salmonids (Mason and Machidori 1976; Patten 1971, 1975) or competitors (Brocksen et al., 1968) for their food and space. These allegations, lacking positive empirical support, have led to "rough-fish" control measures and stream improvement projects, attempting to enhance salmonid populations. The feasibility of such practices, from economical and environmental viewpoints, is presently being questioned, compelling the need for more detailed knowledge concerning stream fish relationships.

Habitat requirements of juvenile salmonid fishes in streams have been intensively studied. These requirements vary according to species, size of fish present, and time of

year. Habitat components important for juvenile salmon and trout include food production areas, quality and quantity of water, cover and space. Reiser and Bjornn (1979) describe in summary these important habitat components. Instream distribution and habitat preference of stream salmonids have been intensively investigated (Everest and Chapman 1972; Fraser 1969; Hartman 1965; Hartman and Gill 1968; Lewis 1965; Lowry 1965; Lister and Genoe 1970; Mason 1966; Saunders and Smith 1962). Boussu (1954) and Butler and Hawthorne (1968) were able to demonstrate the importance of cover to trout populations. Lister and Genoe (1970) found that post-emergent fry of coho (Oncorhynchus kisutch) and chinook (Oncorhynchus tshawytscha) occupied the marginal areas associated with bank cover. Chapman (1966) concluded that food and spatial constraints regulate the size of salmonid populations in streams. The ecological implications of diet preference is discussed by Fraser (1969), Mundie (1969) and Peterson (1966).

Although there is much general knowledge concerning habitat and spatial requirements and co-existence of juvenile salmonids, many studies have ignored their association with non-game fishes (Boussu 1954; Burns 1971; Everest and Chapman 1972; Lister and Genoe 1970).

Importance of non-game fishes as predators on, or competitors of, salmonid populations should be more closely looked at as resource managers seek to understand better the

mechanisms involved in defining fish population dynamics in streams.

Sculpins of the genus Cottus are numerous and well distributed in western Oregon streams (Bond 1963) and have been implicated as both predators on juvenile salmonids and competitors for their food and space. Predation on salmon seems to be limited and incidental (Krohn 1967; Patten 1972). Competition between sculpins and salmonids has for the most part been inferred from apparent diet overlaps although few studies have actually compared diets (Moyle 1977). Moyle (1977) comes to the 'defense of sculpins' by stressing that most severe damage by sculpins is found in those situations where salmonid populations have already been reduced due to over-exploitation or environmental disturbances. He states also the need for more research into possible positive aspects of sculpin-salmonid interactions, such as sculpins providing a food base for salmonids.

Other fishes found in association with salmonid populations in western Oregon streams include many members of Cyprinidae, notably the redside shiner (Richardsonius balteatus) and the speckled dace (Rhinichthys osculus). There have been recent attempts by the Oregon Department of Fish and Wildlife to eradicate populations of both fishes in certain streams in an effort to enhance production of juvenile salmonids. Because the streams under study have

been subjected to several environmental disturbances (logging, channelization, etc.), there exists the need for research to reveal whether these and other non-game fishes are responding to environmental conditions no longer suitable to salmonids or are in fact involved in displacement of salmonids. Therefore the opportunity exists to study specific conditions that can affect stream fish populations. A better understanding of the relationship between the physical habitat and fish populations could have future predictive value in determining the effects of disturbances on the fish community.

The objectives of the present study are:

1. To determine the distribution and abundance of salmonid and non-game fishes in several selected streams on lands of the Bureau of Land Management in the Coos Bay District (Appendix A).

2. To determine the physical conditions that characterize the various habitat types.

3. To determine general food habits of the fishes of the study area.

4. To determine the influence of physical conditions and possible competition for food on the distribution and abundance of fish.

The Study Area

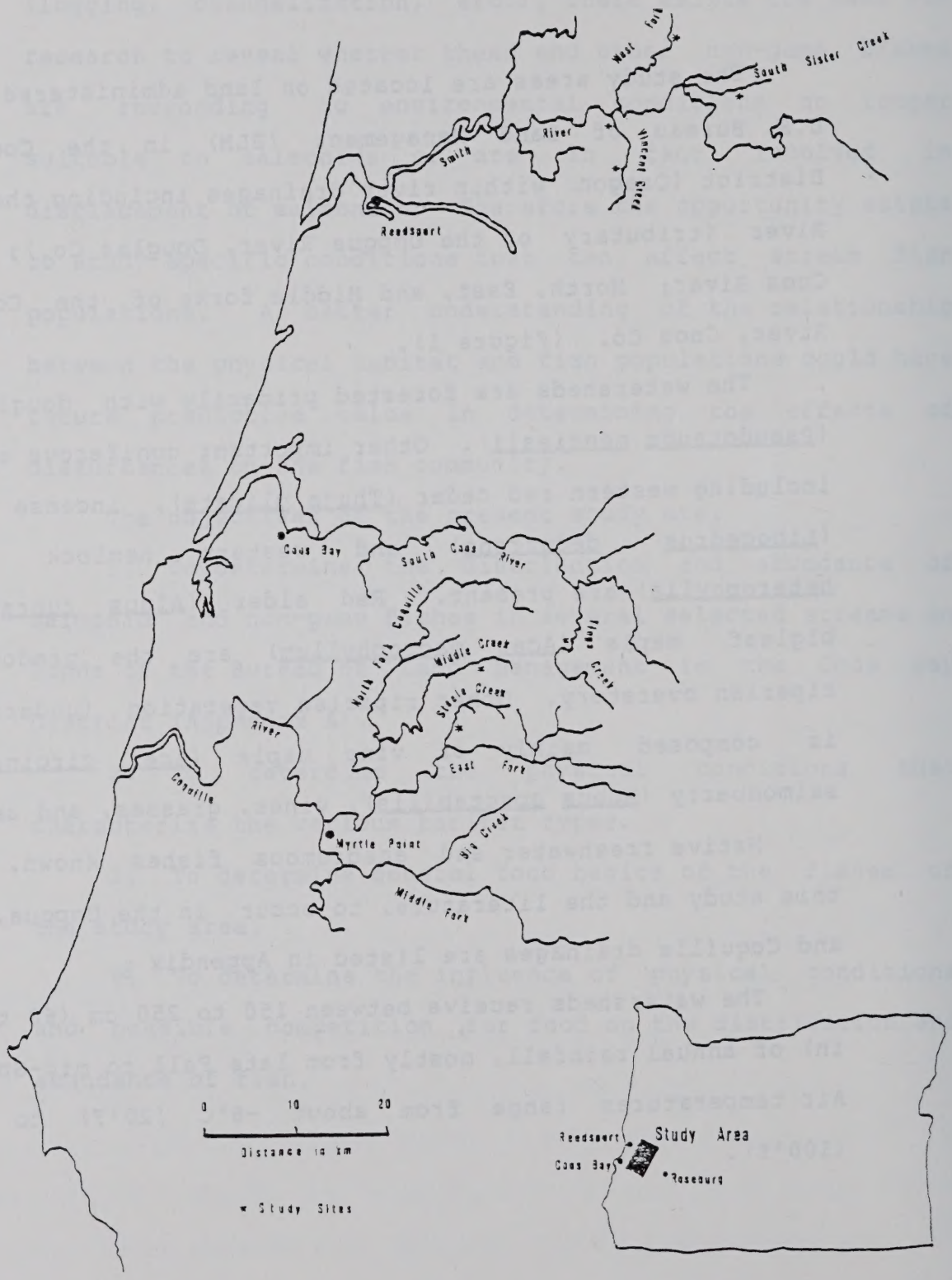
The study areas are located on land administered by the U.S. Bureau of Land Management (BLM) in the Coos Bay District (Oregon) within river drainages including the Smith River (tributary of the Umpqua River, Douglas Co.); South Coos River; North, East, and Middle forks of the Coquille River, Coos Co. (Figure 1).

The watersheds are forested primarily with douglas-fir (Pseudotsuga menziesii). Other important coniferous species including western red cedar (Thuja plicata), incense cedar (Libocedrus decurrens) and western hemlock (Tsuga heterophylla) are present. Red alder (Alnus rubra) and bigleaf maple (Acer macrophyllum) are the predominant riparian overstory. Other riparian vegetation (understory) is composed mainly of vine maple (Acer circinatum), salmonberry (Rubus spectabilis), vines, grasses, and sedges.

Native freshwater and anadromous fishes known, from this study and the literature, to occur in the Umpqua, Coos and Coquille drainages are listed in Appendix B.

The watersheds receive between 150 to 250 cm (60 to 100 in) of annual rainfall, mostly from late Fall to mid-Spring. Air temperatures range from about -6°C (20°F) to 38°C (100°F).

Figure 1. Map of the study area.



Smith River Drainage

The Smith River originates near Drain, in the Coast Range and flows westward into the Umpqua estuary near Reedsport. The river drains approximately 965 square kilometers of lands held in Federal, state and private ownership.

Study areas were established on three streams within the Smith River drainage; Vincent Creek, West Fork Smith River and South Sisters Creek.

Vincent Creek descends about 17 km from an elevation of 244 m to 61 m where it enters the Smith River. Stream gradient in the upper 3 km is 47 m/km. The stream in the lower 14 km drops 5 m/km as it flows over predominantly solid sandstone bedrock, with numerous large instream boulders and fallen trees in the stream. The Vincent Creek basin was partially burned in the 1966 Oxbow fire and is presently an area of active logging. Streamside overstory is only partial and dominated by mixed conifers, red alder, and bigleaf maple. During 1974, 12 rearing pools were created by blasting with dynamite to help improve the riffle to pool ratio and thus increase salmonid rearing capacity in Vincent Creek.

West Fork Smith River originates at an elevation of 460 m and flows south for 21 km into the Smith River at 61 m elevation. The upper 7.5 km of the stream drops 47 m/km and

has several shallow pool and riffle reaches and areas of extensive gravel. The lower 13.5 km has a gradient of 6.7 m/km over predominantly sandstone bedrock, and has numerous deep pools and instream boulders. Streamside overstory, dominated by mixed conifers, red alder and the bigleaf maple, is rather dense along most of the stream. Much of the surrounding watershed is older second growth forest.

South Sisters Creek descends from an elevation of 305 m to 76 m for 13.6 km through a basin totally devastated by the 1966 Oxbow fire. Stream gradient averages 24 m/km in the upper 6.4 km and 10.6 m/km through the lower 7.2 km basin. The substrate is predominantly sandstone bedrock with several areas of gravel and boulders, especially in the upper reaches. The riparian canopy is densely vegetated by young alder along most of the stream length. A stream clearance project was completed in Summer 1970 to clear logjams and debris from the stream and its tributaries in order to enhance anadromous fish passage. In 1973 the Oregon Game Commission rotenoned South Sisters Creek along BLM lands in an attempt to eradicate large populations of redside shiner and speckled dace. South Sisters Creek became intermittent during late Summer 1980 throughout most of its length.

South Coos River Drainage

The South Fork of the Coos River flows into the Coos River near the confluence of the Millicoma River approximately 6.4 km east of Coos Bay. The river is wide with numerous deep pools and swift rocky riffles throughout its length and was difficult to sample adequately. Seasonal sampling in the South Coos River was completed only at Cox Creek confluence when water conditions permitted.

Tioga Creek was the principal study stream in the drainage. The stream drains approximately 123 square kilometers of lands in BLM and private ownership. Tioga Creek descends 29 km from an elevation of 610 m to 152 m through terrain described as generally very steep to extremely steep (60-90%). The stream gradient through the lower 20 km is 6 m/km with the upper reaches flowing through extremely rugged terrain dropping 40 m/km. Two waterfalls are located in the central mainstream and one falls of 4.5 m is located in the upper headwaters.

The stream bottom is predominantly sandstone bedrock. Extensive areas of gravel are available throughout the stream. The riffle to pool ratio is a favorable 41.5% to 58.5% (BLM 1970) streamside overstory is tall and densely vegetated composed mostly, of mixed conifers, red alder and bigleaf maple.

Coquille River Drainage

The North Fork Coquille River Flows into the Coquille River approximately 1.6 km north of Myrtle Point. The areas along the lower to mid reaches are mostly flat pasture land with terrain of slope between 0 to 35%. Middle Creek, the principal study stream within this drainage, flows into the North Fork Coquille at Lee Valley.

Middle Creek begins at 585 m and descends approximately 33 km to its confluence with the North Fork. The gradient of the stream changes rapidly in the upper 9 km stretch (97 to 20 m/km) as it flows under a densely vegetated canopy of red alder, bigleaf maple, myrtlewood (Umbellularia californica), and salmonberry. The lower 25 km of the stream descends 2 m/km through partially shaded areas. Beaver (Castor canadensis) have constructed dams in the upper reaches and were active during Summer 1980.

The East Fork Coquille River enters into the North Fork Coquille River at Gravelford. Areas along the lower reaches of the river are mostly flat pasture land. Upstream movement of salmonids in the East Fork is limited to below Brewster Canyon 45 km upstream from its mouth. The river drops 120 m/km through the canyon. Two falls in the gorge are impassable to fish. The lower falls is 4 m high with a sheer drop; the second falls drops 2.5 m and has a gradient of 45°.

Steele Creek flows 8 km from an elevation of 440 m to 50 m where it enters the East Fork. In the upper 4.5 km, stream gradient is approximately 60 m/km as the stream flows through mostly densely vegetated canopy over both bedrock and gravel areas. In the lower 3.5 km the stream drops 21 m/km. Fallen timber is present throughout the stream and creates numerous pool areas.

The Middle Fork Coquille River originates near Bennett Rock north of Camas Mountain and joins the North Fork Coquille to from the Coquille River.

Big Creek, the study stream in this watershed, empties into the Middle Fork Coquille near the town of Bridge. The river drains approximately 65 square kilometers of lands of BLM and private ownership. In a distance of 26 km, the stream drops from an elevation of 490 m to 40 m. The gradient of the stream decreases from 60 m/km to 30 m/km in the upper reaches and 7 m/km through the lower 13 km. Stream substrate is variable, extending from bare bedrock and gravels, to extremely large boulders. The streamside overstory is mostly densely vegetated by second growth douglas fir, myrtlewood, red alder and willows.

Methods and Materials

Study of fish distribution within the study streams began fall 1979 and continued through summer 1980. In situ biological and ecological monitoring was undertaken at permanent study sites during the summer period of decreasing flow when limitations of space and resources can cause stress in stream fish populations.

Sampling Fish Distribution Within the Study Streams

Fish populations were censused throughout the study streams (Appendix A) at several locations from fall 1979 through summer 1980.

Fish were collected by means of small-mesh beach seines and by shocking with a Dirigo^{R} backpack electroshocker used in conjunction with a dip net. Frame or kick nets were used when collecting fish living among rocks in swift water. Most fish were identified by sight and recorded, then released unharmed. Several individuals of each species were retained and preserved in an 8% formaldehyde solution for laboratory inquiry.

High stream flow precluded adequate winter sampling after the first significant rainfall in several of the larger rivers and streams.

In Situ Data Collection

Individual study sites were isolated with blocking nets and initially sampled with at least four seine passes until

none or few fish were captured. Captured fish were retained in buckets of water with aeration supplied by a battery operated aerator. Each site was next sampled by shocking upstream with the backpack electroshocker until no more fish were collected. Usually only three passes were needed to capture most fish. No attempts were made to determine the relative or absolute efficiencies of the two sampling methods and I assumed that total removal was attained. Seining was most effective in pool-like habitat and was especially useful for capturing coho salmon, electroshocking was most effective in irregular habitats for capturing the cryptic and benthic fishes (e.g. sculpins, dace).

Captured fish were anesthetized with benzocaine. Then individual fork lengths (total length in sculpins) were measured to the nearest millimeter and each fish was weighed to the nearest gram on a triple beam balance. The fish were released into the study section after they recovered from the anesthetic.

Fish populations were sampled at the study sites on four occasions during summer 1980 at three to four week intervals. These intervals reduced disturbance of the fish and allowed enough time for the fish to respond to environmental conditions associated with decreasing flow. A total of 40 observations was concluded. Two sites were sampled only three times and one site was sampled twice.

Ecological Monitoring of the Stream Environment

During May, 1980, 11 permanent monitoring sites were established within the Smith River, South Coos River and North Fork and East Coquille River drainages (Appendix C). Five sites were established within the Smith River drainage with two sites located on both Vincent Creek and West Fork Smith River with a single site on South Sisters Creek. Two sites were located on Tioga Creek within the South Coos River drainage, Middle Creek within the North Fork Coquille drainage and Steele Creek within the East Fork Coquille drainage.

Individual sites were selected on the basis of differing sympatric fish populations, community structure, and varied environmental characteristics (e.g. pool to riffle ratio, percent canopy, substrate composition, etc.) that might help define community structure. Site lengths ranged from 9.3 m (30 ft) to 15.2 m (50 ft) with wooden markers placed at 3.1 m (10 ft) intervals.

At each site, stream width was measured to the nearest centimeter at each segment marker with average width determined by averaging the two measurements of each segment. Surface area was determined for individual segments by multiplying segment length times average width. Total surface area at each site was then calculated through summation of surface areas of all individual segments.

Depth measurements were recorded at each marker across

the stream at 0.3 m (1 ft) intervals beginning 0.15 m from the water's edge. Average depth was calculated for each segment. Site volumes were then determined by computing segment volumes and totaling these for total site volume.

Flow at each site was measured using a pygmy current meter. Average velocity at each site was determined by recording 40 second velocity readings at 1/4, 1/2 and 3/4 width across each segment and then averaging all the readings. Maximum velocity was also recorded for each site.

Elevation of each site was determined from a portable altimeter. Stream gradient for individual sites was measured with a clinometer and total stream gradient was approximated from topographic maps.

The pool to riffle ratio was calculated by dividing the total surface area of the pools by the total surface area of the riffles.

Daily hour maximum and minimum temperatures of air and water were recorded during each sampling period using calibrated maximum-minimum thermometers.

Instream cover usually includes boulders, undercut banks, submerged logs, shade, deep water and turbulent water (Boussu 1954; Bowers et al. 1979; Reiser and Bjornn 1979; Saunders and Smith 1962). However, in this study instream cover included only undercut banks, margins of boulders and miscellaneous submerged debris providing escape cover because several other cover categories were measured as

other discrete categories. Instream cover was recorded as a percentage of total site surface area.

Streamside cover includes tall trees and other riparian vegetation and was estimated as percent canopy over the stream site. Shade cover varies throughout the day and was estimated as percent surface area shaded with the sun directly overhead.

Stream substrate composition was determined through visual estimates of percentages of bare bedrock, boulder (greater than 30 cm in diameter), cobble (15 to 30 cm in diameter), rubble (7.5 to 15 cm in diameter), coarse gravel (2 to 7.5 cm in diameter), fine gravel (.25 to 2.5 cm in diameter), sand and woody debris.

Dissolved oxygen was measured during the last three sampling periods using the Winkler method, but the early September samples were discarded because of chemical uncertainties. A portable pH meter was used to measure pH at each study site on two occasions.

Invertebrate Drift Fauna

Drift net collections over 24 hours were made at seven study sites on the six study streams from June 18 to July 9, 1980. Net contents were preserved in 70% ethyl alcohol and later identified and enumerated at the ordinal and whenever possible, familial level. The combined drift organisms were dried on pre-weighed filter paper at 85°C for 48 hours. This time and temperature had previously been known to be

adequate in removing all water from the sample (Gordon Reeves, personal communication). The drift was expressed as the total dry weight in grams captured per 24 hours.

Food Habits

In early August, collections of fish for analyses of food habits were made from locations near study sites on Vincent, Tioga and Middle creeks representing the Smith, South Coos and North Fork Coquille river drainages, respectively. On each stream discrete sections of approximately 15 m were seined and electroshocked and all fish captured were removed and preserved in 15% formaldehyde solution. No attempt was made to collect equivalent numbers of each species because I assumed that food resources are partitioned to existing natural fish assemblages. A total of 266 fish was collected at the three sites for analyses of food habits. Eighty-five fish were collected from Vincent Creek, 102 from Tioga Creek and 69 from Middle Creek.

In the laboratory, the stomach of each fish was removed and slit, and contents only from the anterior portion of the stomach were removed for identification. The contents of the posterior half of the stomach were generally too far advanced in digestion to be readily identified. Contents were identified according to entire organisms and gross portions of partially digested organisms. Most contents were identified to the family level, although diet composition analyses of food habits for comparison purposes

was analyzed at the ordinal level. Contents were expressed as percentage composition by frequency of occurrence of a particular food category for a given species and percentage composition by frequency of number of a particular food category in the total diet of a given species.

Statistical Analysis

The data were compiled into a matrix containing 40 observations on 42 variables. The data were also compiled into a 33 by 42 matrix deleting the last seven observations in order to test the difference of increasing stream flow on fish populations due to early fall rains.

Bivariate correlation analysis was used to determine the degree of covariance between the biological variables (e.g. number of species, biomass) and environmental variables. The Pearson product-moment correlation coefficient was determined using the Statistical Package for the Social Sciences (SPSS) (Nie et al. 1970) and is calculated according to the formula:

$$r = \frac{\sum x_1 x_2}{[(\sum x_1^2)(\sum x_2^2)]^{1/2}}$$

Results

Data collection of fish distribution within most study streams began fall, 1979, continuing through summer, 1980 (Appendix A). Study streams within the East Fork and Middle Fork Coquille River drainages were initially sampled in winter, 1980. Winter collections were considered as being partial at best because of high water conditions throughout most study streams that prevented adequate sampling. Maps illustrating the relative locations of sites of repeated seasonal collections are contained in Figures 2-5. Twelve species were collected in both Smith River and South Coos River drainages. Nine species were collected from each of the Coquille River drainages, the North Fork, East Fork, and Middle Fork (Appendix D).

Data collected from biological and ecological monitoring over four sampling periods from June to September, 1980 are contained in Tables 1-3. A total of 40 observations was made over the four periods. Tioga Creek (#1) had only two observations, because no, or only a few, fish were found during the third and fourth samples.

Number of fish species collected at the study sites ranged from four on South Sisters Creek and Middle Creek (#1) to six in Tioga Creek (#1) and Vincent Creek (#2). Five species were collected at the seven remaining sites. Coho salmon and steelhead trout (Salmo gairdneri) were

Table 1. Biological data collected June to September, 1980.

Location/Date	Coho Salmon #	Coho Salmon biomass	Steelhead Trout #	Steelhead Trout biomass	Cutthroat Trout #	Cutthroat Trout biomass	Reticulate Sculpin #	Reticulate Sculpin biomass	Riffle Sculpin #	Riffle Sculpin biomass	Speckled Dace #	Speckled Dace biomass	Redside Shiner #	Redside Shiner biomass	Total Salmonoid biomass (g)	Total Non-Salmonoid biomass (g)
South Sisters Creek																
17 June	47	35.4	5	48.2	16	57.1	0	0.0	8	43.9	--	--	--	--	140.7	43.9
3 August	0	0.0	23	103.6	23	102.4	0	0.0	5	31.9	--	--	--	--	206.0	31.9
4 Sept.	0	0.0	14	75.6	18	76.5	0	0.0	0	0.0	--	--	--	--	152.1	0.0
21 Sept.	0	0.0	2	15.8	12	56.0	0	0.0	0	0.0	--	--	--	--	71.8	0.0
West Fork Smith #1																
23 June	33	109.7	13	13.6	0	0.0	24	77.4	7	45.5	--	--	--	--	123.3	122.9
4 August	25	110.9	10	21.5	1	3.5	11	38.1	6	26.9	--	--	--	--	135.9	74.2
4 Sept.	1	3.6	4	9.8	0	0.0	5	18.4	8	43.0	--	--	--	--	33.5	61.4
21 Sept.	32	203.7	10	49.0	0	0.0	10	37.4	2	11.3	--	--	--	--	252.7	48.7
West Fork Smith #2																
24 June	0	0.0	23	62.6	1	40.5	24	71.0	2	10.2	--	--	--	--	62.6	121.7
4 August	2	8.3	8	24.3	1	3.6	11	41.3	1	8.0	--	--	--	--	36.2	57.0
4 Sept.	1	9.5	7	16.8	1	4.3	16	46.4	1	6.0	--	--	--	--	26.6	52.4
Vincent Creek #1																
18 June	1	6.0	1	0.8	--	--	87	143.6	3	18.4	12	31.7	--	--	6.8	103.7
5 August	0	0.0	1	4.3	--	--	38	104.7	28	112.7	4	35.7	--	--	4.3	272.9
5 Sept.	0	0.0	3	10.2	--	--	36	70.8	24	87.6	2	28.0	--	--	10.2	158.4
Vincent Creek #2																
25 June	16	88.4	40	106.9	0	0.0	45	167.7	0	0.0	9	38.9	11	64.6	195.3	271.2
5 August	13	67.1	32	151.3	0	0.0	21	81.8	0	0.0	6	28.7	31	157.3	218.4	275.8
5 Sept.	2	8.3	8	27.1	0	0.0	14	35.8	0	0.0	3	17.3	9	39.8	35.4	92.9
21 Sept.	1	10.5	6	55.0	1	12.0	15	68.7	0	0.0	2	10.5	12	56.6	77.5	135.8

Table 1 . continued

Location/Date	Coho Salmon #	Coho Salmon biomass	Steelhead Trout #	Steelhead Trout biomass	Cutthroat Trout #	Cutthroat Trout biomass	Reticulate Sculpin #	Reticulate Sculpin biomass	Riffle Sculpin #	Riffle Sculpin biomass	Speckled Dace #	Speckled Dace biomass	Long-nose Dace #	Long-nose Dace biomass	Total Salmonoid biomass (g)	Total Non-Salmonoid biomass (g)
Steele Creek #1																
2 July	28	69.5	11	17.9	0	0.0	25	44.8	--	--	0	0.0	--	--	87.4	44.8
8 August	28	72.6	11	30.9	3	46.9	8	15.7	--	--	2	10.2	--	--	150.4	28.1
2 Sept.	19	49.2	5	16.6	3	32.3	13	22.5	--	--	10	37.0	--	--	98.1	59.5
19 Sept.	26	97.0	4	21.4	6	115.0	4	8.9	--	--	5	21.3	--	--	233.4	30.2
Steele Creek #2																
3 July	73	118.0	18	52.3	2	65.0	25	35.0	--	--	0	0.0	--	--	235.3	35.2
8 August	36	98.4	5	42.7	2	48.6	20	30.0	--	--	33	188.4	--	--	189.7	222.9
2 Sept.	29	92.0	9	48.1	2	33.0	18	31.0	--	--	22	94.1	--	--	173.1	125.1
19 Sept.	19	64.0	6	35.7	6	165.5	7	7.8	--	--	15	45.0	--	--	265.2	52.8
Middle Creek #1																
8 July	6	12.8	4	14.2	0	0.0	15	34.5	--	--	--	--	--	--	27.0	34.5
7 August	17	40.4	4	16.1	1	14.7	11	35.2	--	--	--	--	--	--	71.2	35.2
3 Sept.	8	14.3	2	2.9	0	0.0	4	10.5	--	--	--	--	--	--	17.2	10.5
20 Sept.	2	3.4	0	0.0	0	0.0	3	5.5	--	--	--	--	--	--	3.4	5.5
Middle Creek #2																
9 July	127	218.1	13	10.4	0	0.0	27	61.2	--	--	16	11.8	--	--	228.5	73.0
7 August	96	231.6	2	4.3	1	10.3	10	26.2	--	--	14	14.8	--	--	338.9	55.7
3 Sept.	74	179.3	2	17.9	1	8.3	10	15.1	--	--	7	8.2	--	--	197.2	31.6
20 Sept.	55	193.9	1	4.0	0	0.0	6	24.0	--	--	1	3.7	--	--	197.7	27.7
Tioga Creek #1																
10 July	3	13.2	3	4.2	0	0.0	10	21.5	2	10.9	6	17.2	6	26.7	17.4	76.3
6 August	2	10.2	12	36.8	0	0.0	8	25.9	0	0.0	4	14.8	4	15.7	47.0	72.4
Tioga Creek #2																
10 July	48	131.1	7	9.6	0	0.0	8	22.4	16	61.9	16	44.8	--	--	145.2	129.1
6 August	43	151.8	11	17.8	0	0.0	10	29.4	4	15.6	7	35.0	--	--	169.6	84.8
3 Sept.	32	130.3	4	11.2	0	0.0	5	13.1	0	24.2	7	14.0	--	--	141.5	51.1
20 Sept.	6	31.8	1	22.4	0	0.0	2	4.0	10	29.3	5	10.0	--	--	54.7	43.3

present and collected at all 11 sites. Reticulate sculpins (Cottus perplexus) were collected at 10 sites, cutthroat trout (Salmo clarki) at 8 sites, speckled dace at 7 sites, riffle sculpins (Cottus gulosus) at 6 sites with redside shiners and longnose dace (Rhinichthys cataractae) each collected at 1 site.

Coho salmon were the most numerous salmonid, showing peak numbers generally in later June to early July. Steelhead were more abundant than coho at South Sisters Creek (After June), West Fork Smith (#1), Tioga Creek (#1) and Vincent Creek (#2). The reticulate sculpin was the most numerous cottid in most collections when found together with the riffle sculpin, but was excluded from South Sisters Creek. Most cutthroat trout were greater than 10 cm in length, presumably age (1+), except for numerous juveniles collected from South Sisters Creek.

In addition to having a character fish fauna, each stream differed from the others in average width, depth, velocity and flow (Table 2). The streams ranged in average width from 1.81 m at South Sisters Creek (4 Sept.) to 15.48 m at Tioga Creek (#2, 10 July). Average depth ranged from 6.4 cm at South Sisters Creek (4 Aug.) to 36.5 cm for Tioga Creek (#2, 10 July). Summer low flows ranged from 0 l/s in South Sisters Creek (site became intermittent during mid-August) to 45 l/s in Tioga Creek (#2; 3 Sept.). Due to mid-September rains, flow and volume increased on all

Table 2 . Environmental data collected June to September, 1980.

Location and Date	Surface Area (m^2)	Surface Volume (m^3)	Average Width (m)	Average Depth (cm)	Flow (l/sec)	Average Velocity (m/sec)	Temperature (C^o) max.	Temperature (C^o) min.	Percent Pool
South Sisters Creek									
17 June	45.2	5.324	2.96	11.8	7.5	0.021	15.0	8.0	85
3 August	25.9	1.645	1.93	6.4	1.0	0.008	16.0	12.0	100
4 Sept.	9.8	0.811	1.81	6.3	0.0	0.000	14.0	8.5	100
21 Sept.	14.8	1.135	2.17	7.7	0.0	0.000	14.0	9.5	100
West Fork Smith #1									
23 June	77.4	14.935	6.34	19.3	84.0	0.068	15.5	11.0	98
4 August	66.8	9.719	5.48	14.5	31.4	0.039	17.0	13.0	98
4 Sept.	65.9	8.432	5.40	12.8	22.0	0.032	14.0	10.0	98
21 Sept.	69.9	10.066	5.73	14.4	29.5	0.036	13.0	10.0	98
West Fork Smith #2									
24 June	39.9	4.676	3.44	11.7	84.0	0.208	15.5	11.0	10
4 August	37.2	3.070	3.05	8.3	31.4	0.124	17.0	13.0	20
4 Sept.	35.7	2.859	2.93	8.0	22.0	0.094	14.0	10.0	20
Vincent Creek #1									
18 June	121.6	45.570	9.97	37.6	111.0	0.030	14.0	12.0	100
5 August	117.0	35.627	9.59	30.5	56.0	0.019	19.0	13.5	100
5 Sept.	111.4	32.413	9.13	29.1	35.0	0.013	15.5	12.0	100
Vincent Creek #2									
25 June	108.0	28.178	7.07	26.2	105.0	0.056	19.0	14.0	90
5 August	102.0	20.638	6.71	20.2	49.0	0.036	21.0	14.0	100
5 Sept.	97.6	20.395	6.42	20.9	28.0	0.021	13.0	8.5	100
21 Sept.	101.4	24.230	6.67	23.9	29.0	0.018	17.0	11.0	100
Steele Creek #1									
2 July	62.5	6.910	4.45	11.1	38.4	0.078	17.0	13.0	33
8 August	57.7	4.757	4.12	8.2	16.0	0.047	20.0	12.0	45
2 Sept.	55.1	4.649	3.93	8.3	13.0	0.040	17.0	11.0	50

Table 2 . continued

Location and Date	Surface Area (m^2)	Surface Volume (m^3)	Average Width (m)	Average Depth (cm)	Flow (l/sec)	Average Velocity (m/sec)	Temperature (C^o) max.	min.	Percent Pool
Steele Creek #1 - continued									
19 Sept.	55.3	4.866	3.95	8.8	14.0	0.040	14.0	12.0	50
Steele Creek #2									
3 July	45.0	16.539	2.94	23.2	38.4	0.056	17.0	13.0	100
8 August	41.7	7.048	2.76	16.8	16.0	0.035	19.0	11.0	100
2 Sept.	40.8	6.664	2.69	16.3	13.0	0.030	17.0	11.0	100
19 Sept.	41.3	7.235	2.72	17.5	14.0	0.029	15.5	12.0	100
Middle Creek #1									
8 July	39.4	3.743	4.33	9.5	44.0	0.107	14.0	11.5	50
7 August	36.3	2.679	3.99	7.3	23.0	0.075	16.0	12.0	75
3 Sept.	35.7	2.606	3.93	7.3	13.0	0.045	16.0	11.0	90
20 Sept.	35.9	3.163	3.95	8.8	19.0	0.055	14.0	12.0	80
Middle Creek #2									
9 July	96.1	27.612	6.44	28.7	44.0	0.024	15.0	12.0	100
7 August	85.7	20.877	5.71	24.3	23.0	0.014	17.0	11.0	100
3 Sept.	83.9	20.220	5.59	24.1	13.0	0.010	17.0	10.0	100
20 Sept.	88.0	23.850	5.87	27.1	19.0	0.012	15.0	11.0	100
Tioga Creek #1									
10 July	114.7	20.334	7.52	17.7	135.0	0.101	16.0	13.0	80
6 August	102.0	12.897	6.71	12.6	63.0	0.074	19.0	13.0	85
Tioga Creek #2									
10 July	189.0	69.044	15.48	36.5	135.0	0.024	16.0	13.0	100
6 August	182.0	54.844	14.94	30.1	63.0	0.014	19.0	14.0	100
3 Sept.	183.0	51.525	15.03	28.1	45.0	0.011	17.0	13.0	100
20 Sept.	185.0	56.373	15.15	30.5	73.0	0.015	16.0	13.0	100

streams prior to the late-September samples.

Water temperature was highest during August at all sites. The highest (21°C) was recorded at the lower Vincent Creek site (#2). South Sisters Creek had the lowest summer temperature at 8.0°C (in June) and Steele Creek had the largest diurnal temperature range, 8.0°C (in August).

Sandstone bedrock composition ranged from 0% in West Fork (#2), Vincent Creek (#1), and Steele Creek (#1) to 80-90% in Vincent Creek (#2). Percent of the bottom composed of boulders ranged from 0 at both Steele Creek sites to 26-29 for the upper Vincent Creek (#1) site.

Instream submerged cover ranged for 0.5-0.6% at Middle Creek (#2) to 9.7-9.9% at the Steele Creek (#2) site.

Site elevations ranged from 72 m for both Steele Creek sites to approximately 190 m for the South Sisters site (Table 3).

Highest dissolved oxygen was measured at the West Fork Smith sites on 4 August (14 mg/liter) and the lowest was measured on 21 September at South Sisters Creek (4 mg/liter). The pH was consistently within the 5.8 to 6.4 range. (Table 3).

Invertebrate drift over a 24-hour period was measured from six streams (Table 9). Baetidae and Chironomidae were numerically the most important for most streams. Elmidae were of importance in the drift of both South Sisters and Steele creeks, these being relatively small upper headwater

Table 3 . Environmental data collected June to September, 1980.

Location and Date	Substrate (%) Bedrock	Mixed	Percent Boulder	Cover (%) Instream	Elevation (m)	Dissolved Oxygen (mg/l)	pH
South Sisters Creek							
17 June	35	65	6.0	1.0	190	--	--
3 August	45	55	15.0	1.8	--	8.0	5.4
4 Sept.	50	50	25.0	4.7	--	--	--
21 Sept.	50	50	15.0	3.1	--	4.0	6.4
West Fork Smith #1							
23 June	56	44	3.0	1.0	180	--	--
4 August	60	40	2.0	1.1	--	14.0	6.0
4 Sept.	65	35	2.0	1.1	--	--	--
21 Sept.	60	40	2.0	1.0	--	10.0	5.8
West Fork Smith #2							
24 June	0	100	1.0	2.8	180	--	--
4 August	0	100	2.0	3.0	--	14.0	6.0
4 Sept.	0	100	2.0	3.1	--	--	--
Vincent Creek #1							
18 June	0	100	26.0	4.2	135	--	--
5 August	0	100	29.0	4.4	--	--	--
5 Sept.	0	100	31.0	4.7	--	--	--
Vincent Creek #2							
25 June	90	10	4.0	4.8	93	--	--
5 August	80	20	5.0	5.0	--	11.5	6.6
5 Sept.	80	20	5.0	5.3	--	--	--
21 Sept.	85	15	4.0	5.1	--	10.0	6.5
Steele Creek #1							
2 July	0	100	0.0	1.6	72	--	--
8 August	0	100	0.0	1.8	--	12.5	6.1
2 Sept.	0	100	0.0	2.3	--	--	--
19 Sept.	0	100	0.0	2.3	--	11.0	5.8

Table 3 . continued

Location and Date	Substrate (%) Bedrock	Mixed	Percent Boulder	Cover (%) Instream	Elevation (m)	Dissolved Oxygen (mg/l)	pH
Steele Creek #2							
3 July	50	50	0.0	8.9	72	--	--
8 August	60	40	0.0	9.8	--	11.5	6.2
2 Sept.	60	40	0.0	9.8	--	--	--
19 Sept.	60	40	0.0	9.7	--	10.0	6.1
Middle Creek #1							
8 July	2	98	3.0	1.0	135	--	--
7 August	2	98	3.0	1.3	--	12.5	6.2
3 Sept.	2	98	3.0	1.3	--	--	--
20 Sept.	2	98	3.0	1.3	--	10.0	6.1
Middle Creek #2							
9 July	10	90	2.0	0.5	135	--	--
7 August	15	85	2.0	0.6	--	11.0	6.3
3 Sept.	15	85	2.0	0.6	--	--	--
20 Sept.	15	85	2.0	0.6	--	10.0	6.2
Tioga Creek #1							
10 July	24	76	5.0	2.5	170	--	--
6 August	20	80	5.0	2.9	--	12.0	6.5
Tioga Creek #2							
10 July	15	85	15.0	2.5	170	--	--
6 August	10	90	11.0	2.6	--	10.0	6.4
3 Sept.	10	90	10.0	2.6	--	--	--
20 Sept.	10	90	11.0	2.6	--	9.0	6.2

sites. Simuliidae was of major importance to Steele Creek's drift and Lampetra ammocoetes were abundant in the drift of lower Vincent, Steele and Tioga creeks. Lower Vincent Creek (#2) had the highest total dry weight of drift, due to the predominance of lamprey ammocoetes. Steele Creek, with the second highest total dry weight at 0.080 gms/24 hours, surpassed all other sites in the importance of the invertebrate component.

Data from the food habits analysis for Vincent, Tioga and Middle creeks are found in Tables 4-8. The overlapping foods of fish species clearly show varying partitioning of the food resource. For all three creeks, Ephemeroptera and Diptera larvae were numerically the most important components of the diet, contributing most significantly to the speckled dace (71.2%), reticulate sculpin (86.2%), riffle sculpin (91.7%), steelhead trout (81.7%) and coho salmon (43.0%) diets (Table 7). Trichoptera larvae were also important in the diet of speckled dace (16.4%) and were the single largest contributor to the redside shiner diet (26.2%). Diptera adults (11.7%) and coleoptera adults (14.9%) were the next two major contributors in the coho diet, a reflection of its surface feeding habit.

Because dietary differences are related to behavioral differences in feeding, fish were then grouped according to their general feeding strategies. Speckled dace and sculpins are generally characterized as bottom browsers

Table 4 . The percentage composition by frequency of number (N) and occurrence (O) of foods eaten in early August by juvenile coho salmon, steelhead trout, redside shiner, speckled dace, reticulate and riffle sculpins[1] in Vincent Creek.

Food category	Speckled Dace		Reticulate Sculpin		Redside Shiner		Steelhead Trout		Coho Salmon	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Ephemeroptera										
Adult[2]	--	--	--	--	--	--	--	--	1.6	7.1
Larvae	33.7	33.3	28.6	62.5	10.5	8.3	6.6	55.5	8.2	21.3
Diptera										
Adult[2]	--	--	--	--	7.9	12.8	1.5	18.5	9.8	28.6
Larvae	65.8	91.7	64.3	75.0	2.6	4.2	78.9	74.1	31.1	85.7
Trichoptera										
Adult[2]	--	--	--	--	2.6	4.2	--	--	--	--
Larvae	--	--	--	--	28.9	20.8	3.3	3.7	--	--
Hemiptera[2]	--	--	--	--	--	--	2.7	25.9	--	--
Coleoptera										
Adult[2]	--	--	2.4	6.3	21.0	20.8	6.0	40.7	27.0	71.4
Larvae	--	--	--	--	--	--	--	--	1.6	7.1
Plecoptera										
Adult[2]	--	--	--	--	--	--	--	--	1.6	7.1
Larvae	--	--	--	--	--	--	--	--	--	--
Odonata	--	--	--	--	5.2	8.3	--	--	--	--
Formicidae[2]	--	--	--	--	--	--	--	--	1.6	7.1
Lepidoptera[2]	--	--	--	--	--	--	--	--	--	--
Sialidae	--	--	--	--	--	--	--	--	--	--
Collembola[2]	--	--	--	--	--	--	--	--	--	--
Arachnida[2]	--	--	--	--	2.6	4.2	0.3	3.7	--	--
Acarina	--	--	2.4	6.3	7.9	8.3	0.3	3.7	16.4	14.2
Gastropoda	0.5	8.3	--	--	5.2	8.3	0.3	3.7	--	--
Chilopoda[2]	--	--	--	--	--	--	--	--	--	--
Diplopoda[2]	--	--	--	--	--	--	--	--	--	--

Table 4 . continued

Food category	Speckled Dace %N	Speckled Dace %O	Reticulate Sculpin %N	Reticulate Sculpin %O	Redside Shiner %N	Redside Shiner %O	Steelhead Trout %N	Steelhead Trout %O	Coho Salmon %N	Coho Salmon %O
Decapoda	--	--	--	--	2.6	4.2	--	--	--	--
Lampetra spp.	--	--	2.4	6.3	--	--	--	--	--	--
Cottus spp.	--	--	--	--	2.6	4.2	--	--	--	--
No. stomachs examined		12		16		24		27		14
Total food items	187		42		38		332		61	

[1]One riffle sculpin had eaten Trichoptera larvae.

[2]Refers to adult stage, or to terrestrial origin, subject to capture at surface.

Table 5. The percentage composition by frequency of occurrence (O) and number (N) of foods eaten in early August by juvenile coho salmon, steelhead trout, redside shiner, speckled dace, reticulate and riffle sculpins in Tioga Creek.

Food category	Speckled Dace		Reticulate Sculpin		Riffle Sculpin		Redside Shiner		Steelhead Trout		Coho Salmon	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Ephemeroptera												
Adult[1]	--	--	--	--	--	--	--	--	5.8	16.7	--	--
Larvae	3.3	10.0	17.5	50.0	26.1	83.3	--	--	44.1	58.3	15.4	23.2
Diptera												
Adult[1]	--	--	--	--	--	--	--	--	--	--	16.5	30.2
Larvae	63.9	25.0	73.0	25.0	69.6	50.0	--	--	5.8	8.3	15.4	13.9
Trichoptera												
Adult[1]	--	--	--	--	--	--	16.7	40.0	11.8	16.7	6.6	11.6
Larvae	19.7	20.0	1.3	6.3	--	--	--	--			1.1	2.3
Hemiptera[1]	--	--	--	--	--	--	--	--	11.8	16.7	3.3	6.9
Coleoptera												
Adult[1]	--	--	--	--	--	--	--	--	5.8	25.0	20.9	39.5
Larvae	--	--	--	--	--	--	8.3	20.0	2.9	8.3	--	--
Plecoptera												
Adult[1]	--	--	--	--	--	--	8.3	20.0	--	--	--	--
Larvae	--	--	8.1	25.0	4.3	16.7	--	--	--	--	--	--
Odonata	--	--	--	--	--	--	--	--	--	--	--	--
Formicidae[1]	--	--	--	--	--	--	--	--	--	--	1.1	2.3
Lepidoptera[1]	--	--	--	--	--	--	--	--	2.9	8.3	1.1	2.3
Sialidae	1.6	5.0	--	--	--	--	--	--	--	--	3.3	4.6
Collembola[1]	--	--	--	--	--	--	--	--	--	--	3.3	2.3
Arachnida[1]	--	--	--	--	--	--	8.3	20.0	2.9	8.3	3.3	6.9
Acarina	--	--	--	--	--	--	--	--	--	--	2.2	4.6
Gastropoda	--	--	--	--	--	--	--	--	2.9	8.3	--	--
Chilopoda[1]	--	--	--	--	--	--	--	--	--	--	1.1	2.3
Diplopoda[1]	--	--	--	--	--	--	--	--	--	--	--	--

Table 5 . continued

Food category	Speckled Dace %N	Speckled Dace %O	Reticulate Sculpin %N	Reticulate Sculpin %O	Riffle Sculpin %N	Riffle Sculpin %O	Redside Shiner %N	Redside Shiner %O	Steelhead Trout %N	Steelhead Trout %O	Coho Salmon %N	Coho Salmon %O
Lampetra sp.	11.5	10.0	--	--	--	--	--	--	--	--	5.5	4.6
Cottus sp.	--	--	--	--	--	--	--	--	2.9	8.3	--	--
No. fish stomachs examined		20		16		6		5		12		43
Total no. food items	61		74		23		12		34		91	

[1]Refers to adult stage, or to terrestrial origin, subject to capture at surface.

Table 6 . The percentage composition by frequency of number (N) and occurrence (O) of foods eaten in early August by juvenile coho salmon, steelhead and cutthroat trout, speckled dace and reticulate sculpin in Middle Creek.

Food category	Speckled Dace		Reticulate Sculpin		Cutthroat Trout		Steelhead Trout		Coho Salmon	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Ephemeroptera										
Adult[1]	--	--	--	--	--	--	--	--	--	--
Larvae	14.9	43.5	43.5	58.3	--	--	16.7	50.0	20.0	48.0
Diptera										
Adult[1]	--	--	--	--	1.6	33.3	3.3	16.7	15.2	36.0
Larvae	12.3	26.1	17.4	16.7	88.7	62.6	50.0	50.0	32.4	28.0
Trichoptera										
Adult[1]	--	--	--	--	--	--	--	--	--	--
Larvae	28.9	13.0	34.8	8.3	3.2	33.3	--	--	--	--
Hemiptera[1]	--	--	--	--	--	--	20.0	16.7	7.6	8.0
Coleoptera										
Adult[1]	0.9	4.3	--	--	--	--	3.3	16.7	10.5	20.0
Larvae	8.3	17.4	--	--	--	--	--	--	--	--
Plecoptera										
Adult[1]	--	--	--	--	--	--	--	--	--	--
Larvae	10.1	39.1	4.3	8.3	3.2	33.3	6.6	33.4	--	--
Odonata	--	--	--	--	--	--	--	--	--	--
Formicidae[1]	0.4	4.3	--	--	--	--	--	--	--	--
Lepidoptera[1]	0.4	4.3	--	--	--	--	--	--	0.9	4.0
Arachnida[1]	--	--	--	--	--	--	--	--	5.7	24.0
Acarina	--	--	--	--	--	--	--	--	0.9	4.0
Gastropoda	1.2	8.6	--	--	3.2	33.3	--	--	3.8	16.0
Chilopoda[1]	--	--	--	--	--	--	--	--	--	--
Diplopoda[1]	0.4	4.3	--	--	--	--	--	--	--	--
No. stomachs examined	23		12		3		6		25	
Total food items	128		23		62		30		105	

[1]Refers to adult stage, or to terrestrial origin, subject to capture at surface.

Table 7 . The percentage of composition by frequency of number (N) and occurrence (O) of combined totals for Tioga, Vincent and Middle Creeks, of foods eaten in early August by juvenile coho salmon, steelhead and cutthroat trout, redside shiner, speckled dace, reticulate and riffle sculpins.

Food category	Speckled Dace		Reticulate Sculpin		Riffle Sculpin		Redside Shiner		Cutthroat Trout		Steelhead Trout		Coho Salmon	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Ephemeroptera														
Adult[1]	--	--	--	--	--	--	--	--	--	--	0.5	4.4	0.3	1.2
Larvae	20.8	29.1	25.2	56.8	25.0	71.4	9.5	5.5	--	--	10.7	55.5	21.8	20.5
Diptera														
Adult[1]	--	--	--	--	--	--	7.1	8.3	1.6	33.3	1.5	13.3	11.7	31.7
Larvae	50.4	40.0	61.2	40.9	66.7	42.8	2.4	2.8	88.7	66.7	71.0	53.3	21.2	30.5
Trichoptera														
Adult[1]	--	--	--	--	--	--	7.1	8.3	--	--	1.0	4.4	1.9	6.1
Larvae	16.4	12.7	6.5	4.5	4.2	14.3	26.2	13.9	3.2	33.3	2.8	2.2	0.3	1.2
Hemiptera[1]	--	--	--	--	--	--	--	--	--	--	4.8	22.2	3.5	6.1
Coleoptera														
Adult[1]	0.4	1.8	0.7	2.3	--	--	19.0	13.9	--	--	5.1	33.3	14.9	39.0
Larvae	4.0	7.3	--	--	--	--	2.4	2.8	--	--	0.3	2.2	0.3	1.2
Plecoptera														
Adult[1]	--	--	--	--	--	--	2.4	2.8	--	--	--	--	0.3	1.2
Larvae	4.8	16.4	5.0	11.4	4.2	14.3	--	--	3.2	33.3	0.5	4.4	--	--
Odonata	--	--	--	--	--	--	4.8	5.5	--	--	--	--	--	--
Formicidae[1]	0.2	1.8	--	--	--	--	--	--	--	--	--	--	0.6	2.4
Lepidoptera[1]	0.2	1.8	--	--	--	--	--	--	--	--	0.3	2.2	0.6	2.4
Sialidae	0.2	1.8	--	--	--	--	--	--	--	--	--	--	0.9	2.4
Collembola[1]	--	--	--	--	--	--	--	--	--	--	--	--	0.9	1.2
Arachnida[1]	--	--	--	--	--	--	2.4	2.8	--	--	0.5	4.4	2.8	11.0
Acarina	--	--	0.7	2.3	--	--	7.1	5.5	--	--	0.3	2.2	4.1	6.1
Gastropoda	0.8	5.4	--	--	--	--	4.8	5.5	3.2	33.3	0.5	4.4	1.3	4.9
Chilopoda[1]	--	--	--	--	--	--	--	--	--	--	--	--	0.3	1.2
Diplopoda[1]	0.2	1.8	--	--	--	--	--	--	--	--	--	--	--	--

Table 7 . continued

Food category	Speckled Dace %N	Speckled Dace %O	Reticulate Sculpin %N	Reticulate Sculpin %O	Riffle Sculpin %N	Riffle Sculpin %O	Redside Shiner %N	Redside Shiner %O	Cutthroat Trout %N	Cutthroat Trout %O	Steelhead Trout %N	Steelhead Trout %O	Coho Salmon %N	Coho Salmon %O
Decapoda	--	--	--	--	--	--	2.4	2.8	--	--	--	--	--	--
Lampetra spp.	1.5	3.6	0.7	2.3	--	--	--	--	--	--	--	--	1.6	2.4
Cottus spp.	--	--	--	--	--	--	2.4	2.8	--	--	0.3	2.2	--	--
No. stomachs examined		55		44		7		36		3		45		82
Total food items	476		139		24		42		62		393		316	

[1]Refers to adult stage, or terrestrial origin, subject to capture at surface.

Table 8 . The percentage composition by frequency of occurrence (O) and number (N) of early August foods eaten by benthic bottom feeders (speckled dace, reticulate sculpin, riffle sculpin) and opportunistic or drift feeders (redside shiner, coho salmon, steelhead trout, cutthroat trout) in Tioga, Vincent and Middle creeks. Totals for all three streams included.

Food category	Tioga Creek				Vincent Creek				Middle Creek				Total			
	Benthic		Surface		Benthic		Surface		Benthic		Surface		Benthic		Surface	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Ephemeroptera																
Adult[1]	--	--	1.5	3.3	--	--	0.2	1.8	--	--	--	--	--	--	0.3	1.9
Larvae	10.3	35.7	22.5	35.0	31.7	55.2	5.7	35.7	17.5	48.5	14.6	44.1	21.0	45.3	10.2	35.0
Diptera																
Adult[1]	--	--	11.6	21.7	--	--	2.6	21.4	--	--	10.1	32.3	--	--	5.5	22.5
Larvae	70.3	28.6	12.4	11.7	63.5	86.2	71.6	67.8	32.7	25.7	47.8	52.9	53.1	48.1	57.6	39.4
Trichoptera																
Adult[1]	--	--	9.3	15.0	--	--	0.2	1.8	--	--	--	--	--	--	1.5	6.3
Larvae	8.4	16.7	0.8	1.7	3.0	13.8	4.6	30.3	29.5	40.0	8.9	23.5	14.6	23.6	4.9	16.3
Hemiptera	--	--	5.4	8.3	--	--	1.8	14.3	--	--	1.7	8.8	--	--	2.4	10.0
Coleoptera																
Adult[1]	--	--	16.3	33.3	0.4	3.4	8.3	39.3	0.8	2.8	6.7	32.3	0.5	1.9	9.2	33.1
Larvae	0.6	2.4	0.8	1.7	--	--	0.2	1.8	7.5	14.3	--	--	3.1	5.7	0.2	1.2
Plecoptera																
Adult[1]	--	--	0.8	1.7	--	--	0.2	1.8	--	--	--	--	--	--	0.2	1.2
Larvae	4.5	14.3	--	--	--	--	--	--	9.6	14.3	2.2	5.9	4.8	10.4	0.4	1.2
Odonata	--	--	--	--	--	--	0.4	3.6	--	--	--	--	--	--	0.2	1.2
Formicidae[1]	--	--	0.8	1.7	--	--	0.2	1.8	0.4	2.8	--	--	0.2	0.9	0.2	1.2
Lepidoptera[1]	--	--	1.5	3.3	--	--	--	--	0.4	2.8	0.5	2.9	0.2	0.9	0.3	1.8
Sialidae	0.6	2.4	2.3	3.3	--	--	--	--	--	--	--	--	0.2	0.9	0.3	1.2
Collembola[1]	--	--	2 .3	1.7	--	--	--	--	--	--	--	--	--	--	0.3	0.6
Arachnida[1]	--	--	3.9	8.3	--	--	0.4	3.6	--	--	3.4	17.6	--	--	1.5	8.1
Acarina	--	--	1.5	3.3	0.4	3.4	2.6	8.9	--	--	0.5	2.9	0.2	0.9	2.0	5.0
Gastropoda	--	--	0.8	1.7	0.4	3.4	0.6	5.3	1.2	5.7	3.4	11.7	0.6	2.8	1.2	5.0
Chilopoda[1]	--	--	0.8	1.7	--	--	--	--	--	--	--	--	--	--	0.1	0.6
Diplopoda[1]	--	--	--	--	--	--	--	--	0.4	2.8	--	--	0.2	0.9	--	--
Decapoda	--	--	--	--	--	--	0.2	1.8	--	--	--	--	--	--	0.1	0.6

Table 8 . continued

Food category	Tioga Creek				Vincent Creek				Middle Creek				Total			
	Benthic		Surface		Benthic		Surface		Benthic		Surface		Benthic		Surface	
	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O	%N	%O
Lampetra	5.2	4.8	3.9	3.3	0.4	3.4	--	--	--	--	--	--	1.4	2.8	0.6	1.2
Cottus spp.	--	--	0.8	1.7	--	--	0.2	1.8	--	--	--	--	--	--	0.2	1.2
No. stomachs examined	42		60		29		56		35		34		106		160	
Total food items	155		129		236		539		251		178		642		846	

[1] Refers to adult stage, or to terrestrial origin, subject to capture at surface.

Table 9 . Organisms captured with drift net over 24 hour period.

	South Sisters Creek 18 June	West Fork Smith 23 June	Vincent Creek #1 24 June	Vincent Creek #2 18 June	Steele Creek 2 July	Middle Creek 8 July	Tioga Creek 9 July
Ephemeroptera							
Baetidae	22	119	64	58	360	65	48
Ephemerellidae			2	5			
Heptageniidae	7	2		1	6		1
Leptophlebiidae	4	4	6	3	6		46
Tricorythidae							3
Adults (Misc.)			1	3	1	2	
Odonata							
Gomphidae					1		
Plecoptera							
Capniidae	9				4		
Chloroperlidae		1			2	1	5
Nemouridae	9	1				1	1
Perlidae	1			1	17		2
Pteronarcidae							1
Miscellaneous		4	6	1			
Hemiptera							
Veliidae	1	3		2	3		
Terrestrial adult	1	2		1			
Miscellaneous					2		3
Trichoptera							
Brachycentridae	1				4	1	
Leptoceridae				2			
Limnephilidae	1	1		2			
Philopotamidae	2	1	1	5	9		
Psychomyiidae							2
Adults (Misc.)				1			
Miscellaneous							13

Table 9 . continued

	South Sisters Creek 18 June	West Fork Smith 23 June	Vincent Creek #1 24 June	Vincent Creek #2 18 June	Steele Creek 2 July	Middle Creek 8 July	Tioga Creek 9 July
Coleoptera							
Dytiscidae	1	1					
Elmidae	2	2	1	3	61		22
Elmidae (adult)	33				38		
Hydrophilidae			1	1			
Psephenidae					3		
Curculionidae (adult)	1						
Adults (Misc.)		2	2	3		2	3
Diptera							
Ceratopogonidae		2		4			4
Chironomidae	4	40	87	62	60	9	145
Chironomidae (adult)				3			
Dixidae	3	16			6	1	2
Rhagionidae				1			
Simuliidae		11	3	12	248	5	9
Adults (Misc.)	2				7		4
Hymenoptera							
Formicidae	1	1					
Vespidae		1					
Lampetra ammocoetes				126	45	4	98
Salmonid fingerling			3	1			1
Cottus juvenile	12				1		3
Total grams/24 hours (dry weight)	0.069	0.020	0.010	0.101	0.080	0.022	0.011

(Moyle, 1976) and were grouped as benthic feeders. Redside shiner, steelhead and cutthroat trout and coho salmon are generally opportunistic-drift feeders and grouped accordingly (Table 8). Again, the widespread overlapping of food was illustrated, with Ephemeroptera, Diptera and Trichoptera larva contributing 88.7% of the benthic diet and 72.7% of the opportunistic-drift diet. Adult and terrestrial invertebrates, most likely captured at the surface, contributed only 0.9% to the benthic species diet and 21.2% to the opportunistic-drift diet.

Relationship of Biological and Physical Variables

Multiple correlation analyses were used in attempts to determine the relationships between fish numbers and total biomass in an area and the physical variables measured. Significant correlations are summarized in Table 11.

Thirty-three observations from 11 sites were utilized in the final analysis (Table 10). Seven late September observations were excluded because early fall rains resulted in large increases in available area with fish populations not having sufficient time to respond to physical changes.

Coho numbers revealed significant positive correlation ($p=0.05$) with site length, maximum depth and percent sand. Coho biomass was also correlated positively with site length, maximum depth, volume, surface area, pool ratio, and percent sand.

Table 10. Pearson product-moment correlation coefficients for 42 biological and environmental variables. Correlations significant at the 95 percent level of confidence are followed by an asterisk.

		1. No. of Coho	2. Biomass, Coho	3. No. of Steelhead	4. Biomass, Steelhead	5. No. of Cutthroat	6. Biomass, Cutthroat	7. No. of Reticulate Sculpin	8. Biomass, Reticulate Sculpin	9. No. of Riffle Sculpin	10. Biomass, Riffle Sculpin	11. No. of Speckled Dace	12. Biomass, Speckled Dace	13. No. of Redside Shiner	14. Biomass, Redside Shiner	15. Biomass, Salmonid	16. Biomass, Non-Salmonid	17. Julian day	18. Elevation	19. Site Length	20. Ave. Width	21. Max. Width
1.	No. of Coho	1.00	.91*	-.03	-.15	-.14	.19	-.05	-.11	-.15	-.17	.32	.08	-.11	-.11	.73*	-.12	-.22	-.22	.43*	.12	.13
2.	Biomass, Coho		1.00	.05	-.10	-.27	.07	-.04	.03	-.14	-.18	.39*	.18	-.01	.00	.79*	.01	-.14	-.24	.42*	.31	.30
3.	No. of Steelhead			1.00	.86*	.13	.09	.12	.41*	.25	-.23	-.04	-.04	.60*	.63*	.40*	.37*	-.35*	-.11	.23	-.11	-.15
4.	Biomass, Steelhead				1.00	.40*	.31	-.03	.18	-.25	-.22	.02	.10	.70*	.72*	.42*	.35*	-.12	-.09	.18	-.27	-.30
5.	No. of Cutthroat					1.00	.72	-.19*	.43*	.06	.01	-.21	-.16	-.13	-.13	.21	-.35*	.10	.39*	-.28	-.44*	-.43*
6.	Biomass, Cutthroat						1.00	-.32	-.41*	.22	-.19	-.05	.04	-.18	-.18	.54*	-.31	.07	.03	-.04	-.51*	-.49*
7.	No. of Reticulate Sculpin							1.00	.88*	.18	.18	.25	.20	.13	.14	-.17	.65*	-.45*	-.31	.18	.24	.28
8.	Biomass, Reticulate Sculpin								1.00	.20	.20	.14	.12	.36*	.38*	-.11	.78*	-.47*	-.21	.18	.25	.27
9.	No. of Riffle Sculpin									1.00	.98*	-.05	.03	-.15	-.15	-.29	.38*	.00	.24	-.07	.51*	.55*
10.	Biomass, Riffle Sculpin										1.00	-.10	-.01	-.16	-.16	-.29	.37*	-.07	.30	-.06	-.44*	.48*
11.	No. of Speckled Dace											1.00	.90*	.03	.04	.31	.47*	-.02	-.44*	.40*	.21	.19
12.	Biomass, Speckled Dace												1.00	.06	.07	.21	.55*	.07	-.48*	.32	.09	.07
13.	No. of Redside Shiner													1.00	.99*	.21	.53*	-.02	-.21	.25	.06	.04
14.	Biomass, Redside Shiner														1.00	.23	.55*	.04	-.21	.25	.06	.04
15.	Biomass, Salmonid															1.00	.04	-.12	-.22	.39*	-.04	-.05
16.	Biomass, Non-Salmonid																1.00	-.27	-.28	.33	.33	.34
17.	Julian day																	1.00	.03	-.29	-.11	-.13
18.	Elevation																		1.00	-.47*	.12	.08
19.	Site Length																			1.00	.10	.13
20.	Ave. Width																				1.00	.99*
21.	Max. Width																					1.00
22.	Ave. Depth																					
23.	Max. Depth																					
24.	Station Volume																					
25.	Station Surface area																					
26.	Flow																					
27.	Ave. Velocity																					
28.	Max. Temperature																					
29.	Min. Temperature																					
30.	Pool/riffe ratio																					
31.	Canopy																					
32.	Shade																					
33.	Bedrock																					
34.	Mixed Substrate																					
35.	Boulder																					
36.	Cobble																					
37.	Rubble																					
38.	Course Gravel																					
39.	Small Gravel																					
40.	Sand																					
41.	Wood																					
42.	Instream Cover																					

		22. Ave. Depth	23. Max. Depth	24. Station Volume	25. Station Surface area	26. Flow	27. Ave. Velocity	28. Max. Temperature	29. Min. Temperature	30. Pool/riffe ratio	31. Canopy	32. Shade	33. Bedrock	34. Mixed Substrate	35. Boulder	36. Cobble	37. Rubble	38. Course Gravel	39. Small Gravel	40. Sand	41. Wood	42. Instream Cover
1.	No. of Coho	.13	.59*	.26	.20	.00	-.27	.15	.05	.30	-.24	-.23	-.02	.02	-.33	-.13	-.14	-.17	.11	.54*	.09	-.13
2.	Biomass, Coho	.17	.68*	.40*	.38*	.03	-.30	.32	.22	.35*	-.28	-.28	.07	-.07	-.33	-.22	-.22	-.29	-.03	.64*	.06	-.11
3.	No. of Steelhead	-.06	.03	-.05	-.03	.17	.21	.36*	.33	-.08	.05	.08	.57*	-.57*	-.21	-.24	-.08	-.31	-.32	-.31	-.24	-.22
4.	Biomass, Steelhead	-.18	-.15	-.20	-.20	-.04	-.02	.37*	.11	.04	.21	.21	.62*	-.62*	-.11	-.26	-.15	-.38	-.28	-.39	-.17	.35*
5.	No. of Cutthroat	-.32	-.41*	-.38*	-.47*	-.30	-.32	-.23	-.48*	.15	.46*	.43*	.15	-.15	.21	-.29	-.18	-.20	.22	-.23	.21	-.02
6.	Biomass, Cutthroat	-.29	-.25	-.38*	-.50*	-.39*	-.20	-.03	-.39	.11	.33	.35*	.08	-.08	-.06	-.11	.02	-.16	.14	-.18	.27	.15
7.	No. of Reticulate Sculpin	.37*	.44*	.36*	.26	.42*	.09	.01	.34	.08	-.52	-.48*	-.04	.04	.39*	.01	.01	.00	.14	-.10	-.17	.29
8.	Biomass, Reticulate Sculpin	.35*	.44*	.33	.29	.48*	.19	.16	.45*	.02	-.53*	-.47*	.15	-.15	.28	-.11	-.02	-.08	-.05	-.16	-.25	.21
9.	No. of Riffle Sculpin	.24	.34	.49*	.44*	.26	-.25	.00	.23	.28	-.39*	-.41*	-.17	.17	.72*	-.29	-.23	-.05	.32	.22	-.15	-.04
10.	Biomass, Riffle Sculpin	.21	.30	.42*	.37*	.29	-.22	-.05	.17	.28	-.33	-.34*	-.11	.11	.69*	-.33	-.25	-.05	.37*	.14	-.18	-.90
11.	No. of Speckled Dace	.16	.34*	.33	.27	.13	-.24	.29	.13	.30	-.14	-.21	.14	-.14	-.05	-.04	-.19	-.27	-.15	.27	.03	.50*
12.	Biomass, Speckled Dace	.07	.15	.16	.13	.01	-.19	.37*	.11	.25	.00	-.05	.20	-.20	-.01	.02	-.16	-.27	-.22	.06	.01	.65*
13.	No. of Redside Shiner	.03	.15	.07	.15	.09	-.06	.38*	.24	.16	-.08	-.08	.55*	-.55*	-.06	-.21	-.23	-.43	-.42	-.16	-.13	.21
14.	Biomass, Redside Shiner	.04	.16	.08	.15	.11	-.05	.40*	.26	.15	-.08	-.10	.56*	-.56	-.06	-.21	-.24	-.43*	-.42*	-.17	-.13	.21
15.	Biomass, Salmonid	-.03	.39*	.10	.05	-.15	-.36	.40*	.08	.38*	.00	.00	.35*	-.35*	-.32	-.32	-.29	-.47*	-.07	.29	.08	.12
16.	Biomass, Non-Salmonid	.28	.45*	.41*	.38*	.40*	-.03	.42*	.45*	.23	-.43*	-.43*	.33	-.33	.32	-.25	-.22	-.32	-.16	-.07	-.25	.44*
17.	Julian Day	.00	-.18	-.18	-.16	-.72*	-.42*	-.06	-.32	.13	.10	.14	-.04	.04	.08	-.05	-.06	-.20	-.11	.11	.34	.12
18.	Elevation	.07	-.15	.05	.04	.18	.03	-.43*	-.24	.01	-.09	-.10	-.09	.09	.32	-.52*	-.14	.02	.19	.17	.01	-.51*
19.	Site Length	.17	.45*	.18	.29	.24	-.02	.44*	.31	.03	-.25	-.32	.30	-.30	-.33	.00	-.14	-.14	.10	.05	-.29	.19
20.	Ave. Width	.39*	.63*	.95*	.97*	.56*	-.25	.19	.52*	.31	-.52*	-.66*	-.13	.13	.43*	-.32	-.35*	-.18	-.01	.75*	-.16	-.14
21.	Max. Width	.37*	.66*	.95*	.97*	.55*	-.29	.19	.50*	.32	-.52*	-.66*	-.15	.15	.46*	-.29	-.35*	-.17	.07	.73*	-.18	-.16
22.	Ave. Depth	1.00	.40*	.47*	.40*	.25	-.05	-.10	.12	.06	-.61*	-.50*	-.12	.12	.24	-.23	.05	.01	-.01	.25	-.15	.09
23.	Max. Depth		1.00	.74*	.71*	.32	-.40*	.19	.33	.49*	-.73*	-.77*	.07	-.07	.25	-.44*	-.41*	-.39*	.21	.62*	-.09	-.08
24.	Station Volume			1.00	.94*	.58*	.33	.16	.49*	.42*	-.61*	-.71*	.07	-.07	.49*	-.41*	-.39*	-.28*	.01	-.73*	-.11	-.01
25.	Station Surface Area				1.00	.59*	.25	.27	.55*	.30	-.56*	-.73*	-.04	.04	.35*	-.33	-.40*	-.23	.01	.73*	-.20	-.11
26.	Flow					1.00	.29	.03	.38*	.01	-.32	-.47*	.03	-.03	.19	-.15	-.17	.07	.01	.15	-.30	-.13
27.	Ave. Velocity						1.00	-.06	.15	-.79*	.02	.11	-.23	.23	-.40*	.45*	.71*	.67*	-.19	-.45*	-.28	-.10
28.	Max. Temperature							1.00	.67*	-.05	-.03	-.12	.10	-.11	-.16	.13	-.07	-.10	-.10	.11	-.10	.22
29.	Min. Temperature								1.00	-.06	-.30	-.38*	-.06	.06	.11	.10	-.05	.05	-.07	.22	-.24	.06
30.	Pool/riffe Ratio									1.00	-.04	-.16	.46*	-.46*	.35*	-.59*	-.81*	-.79*	-.02	.41*	.16	.19
31.	Canopy										1.00	.89*	.27	-.27	-.39*	.29	-.07	-.04	-.20	-.39*	.17	.09
32.	Shade											1.00	.21	-.21	-.47*	.29	.22	.06	-.27	-.52*	.14	.09
33.	Bedrock												1.00	1.00*	.22	-.50*	-.60*	-.73*	-.32	-.26	.20	.38*
34.	Mixed Substrate													1.00	.22	.50*	.59*	.73*	.32	.26	.20	-.38*
35.	Boulder														1.00	-.35*	-.32	-.16	.33	.19	.09	.07
36.	Cobble															1.00	.64*	.75*	.05	-.33	-.10	-.03
37.	Rubble																1.00	.82*	-.05	-.34*	-.14	-.13
38.	Course Gravel																	1.00	.30	.23	-.28	-.35*
39.	Small Gravel																		1.00	.04	.26	-.37*
40.	Sand																			1.00	.14	-.27
41.	Wood																				1.00	.05
42.	Instream Cover																					1.00

Steelhead trout numbers were correlated positively with maximum temperature and percent bedrock. Negative correlations were found with Julian day and percent mixed substrate. Steelhead biomass was positively correlated with maximum temperature, percent bedrock and percent instream cover. Significant negative correlations were found with percent mixed substrate, percent coarse gravel, and percent sand.

Cutthroat trout numbers were significantly correlated positively with elevation, percent canopy, and percent shade. Negative correlations resulted with average and maximum width, maximum depth, volume, surface area and minimum temperature. Biomass was correlated with percent shade. Negative correlations occurred with average and maximum width, volume, surface area, flow, and minimum temperature.

Reticulate sculpin numbers were positively correlated with average and maximum depth, volume, flow, and percent boulders. Negative correlations occurred with Julian day, percent canopy and percent shade. Biomass was correlated positively with average and maximum depths, flow, and minimum temperature. Negative correlations were again with Julian day, percent canopy, percent shade.

Riffle sculpin numbers were significantly correlated with average and maximum width, volume, surface area, and percent boulder. Negative correlations occurred with

Table 11. Summary of significant bivariate correlations (α=.05), number of fish, bimass of fish and environmental and biological variables from June to September 1980. The sign of correlation is enclosed within parenthesis; Biomass is designated by grams.

Coho Salmon				Steelhead Trout			
numbers		biomass		numbers		biomass	
site length	(+)	site length	(+)	Julian day	(-)	maximum temp.	(+)
maximum depth	(+)	maximum depth	(+)	maximum temp.	(+)	percent bedrock	(+)
percent sand	(+)	volume	(+)	percent bedrock	(+)	percent mixed substrate	(-)
biomass, coho	(+)	surface area	(+)	percent mixed substrate	(-)	percent coarse gravel	(-)
biomass, salmonid	(+)	percent pool	(+)	biomass, steelhead	(+)	percent sand	(-)
		percent sand	(+)	biomass, reticulate sculpin	(+)	percent instream cover	(+)
		no. of speckled dace	(+)	no. of redside shiner	(+)	no. of cutthroat	(+)
		biomass, salmonid	(+)	biomass, redside shiner	(+)	no. of redside shiner	(+)
				biomass, salmonid	(+)	biomass, redside shiner	(+)
				biomass, non-salmonid	(+)	biomass, salmonid	(+)
						biomass, non-salmonid	(+)

Cutthroat Trout				Reticulate Sculpin			
numbers		biomass		numbers		biomass	
elevation	(+)	average width	(-)	Julian day	(-)	Julian day	(-)
average width	(-)	maximum width	(-)	average depth	(+)	average depth	(+)
maximum width	(-)	volume	(-)	maximum depth	(+)	maximum depth	(+)
volume	(-)	surface area	(-)	volume	(+)	flow	(+)
surface area	(-)	flow	(-)	flow	(+)	minimum temp.	(+)
minimum temp.	(-)	minimum temp.	(-)	percent canopy	(-)	percent canopy	(-)
percent canopy	(+)	percent shade	(+)	percent shade	(-)	percent shade	(-)
percent shade	(+)	biomass, reticulate sculpin	(-)	percent boulder	(+)	no. of redside shiner	(+)
biomass, cutthroat	(+)	biomass, salmonid	(+)	biomass, reticulate sculpin	(+)	biomass, redside shiner	(+)
no. of reticulate sculpin	(-)			biomass, non-salmonid	(+)	biomass, non-salmonid	(+)
biomass, reticulate sculpin	(-)						
biomass, non-salmonid	(-)						

Table 11 . continued

Riffle Sculpin				Speckled Dace			
numbers		biomass		numbers		biomass	
average width	(+)	average width	(+)	elevation	(-)	elevation	(-)
maximum width	(+)	maximum width	(+)	site length	(+)	maximum temp.	(+)
volume	(+)	volume	(+)	maximum depth	(+)	percent instream cover	(+)
surface area	(+)	surface area	(+)	percent instream cover	(+)	biomass, non-salmonid	(+)
percent canopy	(-)	percent shade	(-)	biomass, speckled dace	(+)		
percent shade	(-)	percent boulder	(+)	biomass, non-salmonid	(+)		
percent boulder	(+)	percent small gravel	(+)				
biomass, riffle sculpin	(+)	biomass, non-salmonid	(+)				
biomass, non-salmonid	(+)						

Redside Shiner				Salmonid biomass		Non-salmonid biomass	
numbers		biomass					
maximum temp.	(+)	maximum temp.	(+)	site length	(+)	maximum depth	(+)
percent bedrock	(+)	percent bedrock	(+)	maximum depth	(+)	volume	(+)
percent mixed substrate	(-)	percent mixed substrate	(-)	average velocity	(-)	surface area	(+)
percent coarse gravel	(-)	percent coarse gravel	(-)	maximum temp.	(+)	flow	(+)
percent small gravel	(-)	percent small gravel	(-)	percent pool	(+)	maximum temp.	(+)
biomass, redside shiner		biomass, non-salmonid	(+)	percent bedrock	(+)	minimum temp.	(+)
biomass, non-salmonid	(+)			percent mixed substrate	(-)	percent canopy	(-)
				percent coarse gravel	(-)	percent shade	(-)
						percent instream cover	(+)

percent canopy and percent shade. Biomass was correlated positively with average and maximum width, volume, surface area, percent boulder, and percent small gravel. Only percent shade revealed a significant negative correlation.

Speckled dace numbers were correlated positively with site length, maximum depth, and instream cover. Negative correlations were revealed only with elevation. Biomass correlated positively with maximum temperature and instream cover. Elevation was the sole negatively correlated variable.

Redside shiner numbers and biomass revealed corresponding correlations. Positive correlations were with maximum temperature and percent bedrock, but significant negative correlations were with percents mixed substrate, coarse and small gravel.

Total salmonid biomass was positively correlated with site length, maximum depth, maximum temperature, pool ratio and percent bedrock. Negative correlations occurred with average velocity, and percent mixed substrate and percent coarse gravel.

Total non-salmonid biomass revealed positive correlations with maximum depth, volume, surface area, flow, maximum and minimum temperature, and instream cover. Negative correlations were with percent canopy and percent shade

Relationship among biological variables

Coho numbers were correlated positively with coho biomass and total salmonid biomass. Coho biomass was also correlated positively with numbers of speckled dace.

Steelhead trout numbers and biomass were correlated positively with each other and both were correlated with numbers and biomass of redside shiner and total salmonid and non-salmonid biomass. Steelhead trout numbers were correlated positively with reticulate sculpin biomass. Steelhead biomass correlated positively with cutthroat trout numbers.

Cutthroat trout numbers were correlated positively with cutthroat biomass and negatively correlated with number and biomass of reticulate sculpin and total non-salmonid biomass. Biomass was positively correlated with total salmonid biomass and negatively correlated with reticulate sculpin biomass.

Numbers of reticulate sculpin were positively correlated with biomass of both reticulate sculpin and total non-salmonids. Biomass was positively correlated with number and biomass of redside shiner and non-salmonid biomass.

Riffle sculpin numbers and biomass were correlated positively with each other and with non-salmonid biomass.

Speckled dace numbers and biomass were correlated positively with one another and with non-salmonid biomass.

DISCUSSION

Distribution of Fishes in Each Drainage

The summary of fish distribution within the study streams includes data from collections during fall, 1979 and spring to summer, 1980. High water conditions during winter, 1980 precluded adequate sampling in most streams.

Smith River Drainage

A total of 12 species was collected from the Smith River drainage from fall, 1979 to summer 1980 (Appendix C and Figure 2) but only seven of these species were taken in Vincent Creek, West Fork Smith and South Sisters Creek.

The Umpqua dace (Rhinichthys evermanni), Umpqua squawfish (Ptychocheilus umpquae), largescale sucker (Catostomus macrocheilus) and prickly sculpin (Cottus asper) were collected only from the Smith River, but the prickly sculpin was not collected above Smith River falls. Minor obstructions of only 30 cm, have been shown to prevent upstream movement of prickly sculpin (Mason and Machidori 1976).

The reticulate sculpin was the most widespread fish collected in the drainage. Increasing gradient and instream obstructions seemed not to to hinder upstream sculpin distribution, with populations found in the upper-most reaches of Vincent Creek during summer intermittent flows and also in small tributaries into the West Fork Smith. The

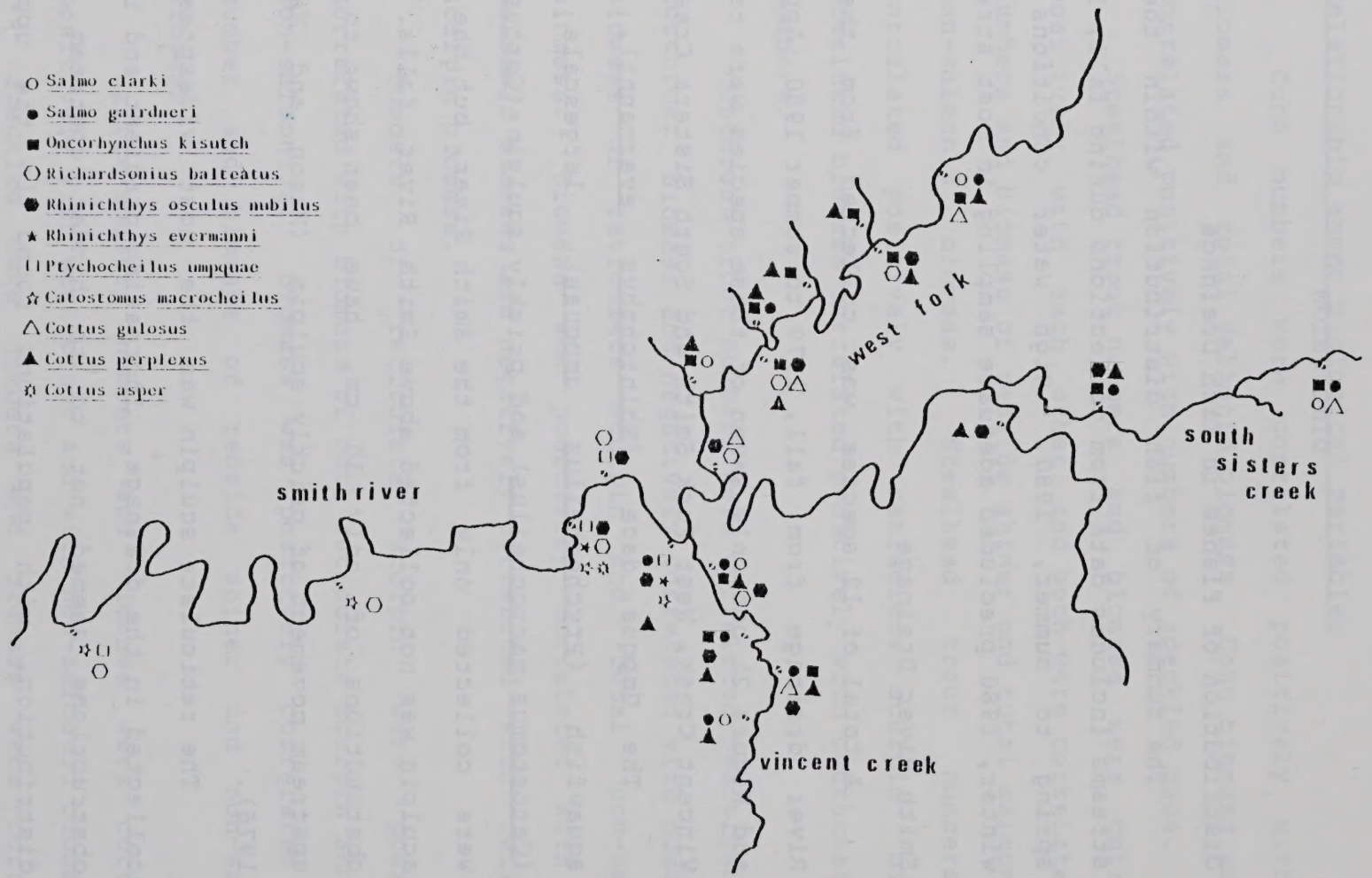


Figure 2. Map of study streams, Vincent Creek, West Fork Smith and South Sisters Creek, within the Smith River drainage, showing relative locations of fish species collected Fall to Summer, 1980.

sculpin was not found in the intermittent reaches of South Sisters Creek, and was confined during summer 1980 to the streams lower permanent reaches. The reticulate sculpin was collected from several bedrock reaches in the Smith River.

Riffle sculpin distribution tended to be patchy. Populations were sometimes found together with the reticulate sculpin but were often found as segregated populations. The riffle sculpin was collected far upstream (above 18 km) in West Fork Smith but was not found in the West Fork's smaller tributaries as was the reticulate sculpin.

Speckled dace were widely distributed and usually abundant, yet were not collected from the upper reaches of the three streams. They were usually collected as solitary individuals, but were observed during summer, 1980 in loose aggregations in several pools in lower Vincent Creek.

Redside shiners were most abundant in the bedrock reaches of the Smith River and were found with irregularity during fall and spring in the downstream bedrock reaches of the three study streams. They were observed during late June migrating upstream in all three streams. Redside shiners were collected upstream to 16.5 km in West Fork Smith during September 1980 without observable obstructions hindering further upstream movement.

Cutthroat trout were the least abundant of the three salmonids collected in the Smith River drainage. They were

usually observed or collected as solitary individuals (Age I+) throughout the mid and lower reaches of the streams with smaller (Age 0+) juveniles especially abundant in the intermittent reaches of the South Sisters Creek. They were especially common in the low and mid reaches of the streams where adequate pool/riffle reaches occurred with suitable escape cover.

Steelhead trout were widespread throughout the drainage with several individuals collected from the limited riffle reaches in the Smith River.

Coho salmon were also widespread and abundant in the study streams, especially during late spring through summer, wherever adequate pools with uninterrupted flow occurred. They were never collected from the Smith River. Known avian predators of fishes, including belted kingfishers (Mergacervle alcyon) and adult and fledgling common Mergansers (Mergus merganser), were frequently observed along the Smith River and its tributaries. Elson (1962) demonstrated increased numbers of atlantic salmon smolts (3 to 5X) when mergansers were removed from study streams. On several occasions, common garter snakes (Thamnophis sirtalis) were observed attempting to capture smaller fish, mostly speckled dace and steelhead trout. Garter snakes (Thamnophis cyrtopsis) were thought to be important predators of fishes in intermittent streams of southeastern Arizona (John 1964).

South Coos River Drainage

Twelve species of fish were collected from the South Coos River drainage from fall, 1979 to summer, 1980 (Appendix C and Figure 3).

Largescale sucker and threespine stickleback (Gasterosteus aculeatus) were collected only in the South Coos River in quiet streamside pools with abundant instream cover.

Longnose dace were abundant throughout both the South Coos and Tioga Creek. They inhabited the faster riffles in the South Coos, yet were also collected from several pools of moderate current among rocks in Tioga Creek. Two studies from Canada demonstrated that longnose dace showed a preference for fast riffles (> 45-50 cm/sec) when sympatric with other species of dace (Gee and Northcote 1963; Gibbons and Gee 1972). Possibly increased spatial stress (two species of dace and sculpins were found in riffle reaches in the South Coos) restricts the longnose dace to its supposed optimal fast riffle habitat in the South Coos.

Speckled dace were collected in abundance in the South Coos and Tioga Creek but were excluded from Shotgun Creek by the severe steep barrier at its entrance. They were not collected from Burnt Creek, despite the absence of a barrier.

Redside shiner were common in the South Coos in

Figure 3. Map showing relative locations of fish species collected from Shotgun, Burnt and Tioga Creeks and South Coos River within the Coos River drainage.

collections at Cox Creek yet were rarely observed upriver or in Tioga Creek. Several large pools could not be adequately sampled due to their width and depth. Few individuals were captured in Tioga Creek for diet analysis and were not observed or collected in Burnt Creek.

Chinook salmon were collected in several pools throughout Tioga Creek in fall, 1979 yet only very few individuals were captured during summer, 1980, possibly due to early downstream migration or poor spawning success.

Coho salmon were abundant throughout Tioga Creek, especially upstream from Shotgun Creek. They were collected in Burnt Creek also.

Cutthroat and steelhead (rainbow) trout were the only fish species collected from Shotgun Creek and were not particularly abundant in this small stream. The high culvert at the mouth of Shotgun Creek was lowered in 1974, in the hope of improving upstream passage of coho and steelhead while still excluding non-game fishes.

Coquille River Drainage

North Fork Coquille River Drainage

Nine species of fish were collected from the North Fork Coquille River drainage from fall, 1979 to summer, 1980 (Appendix C and Figure 4).

The North Fork Coquille River, a wide, low gradient river upstream through LaVerne County Park, is characterized

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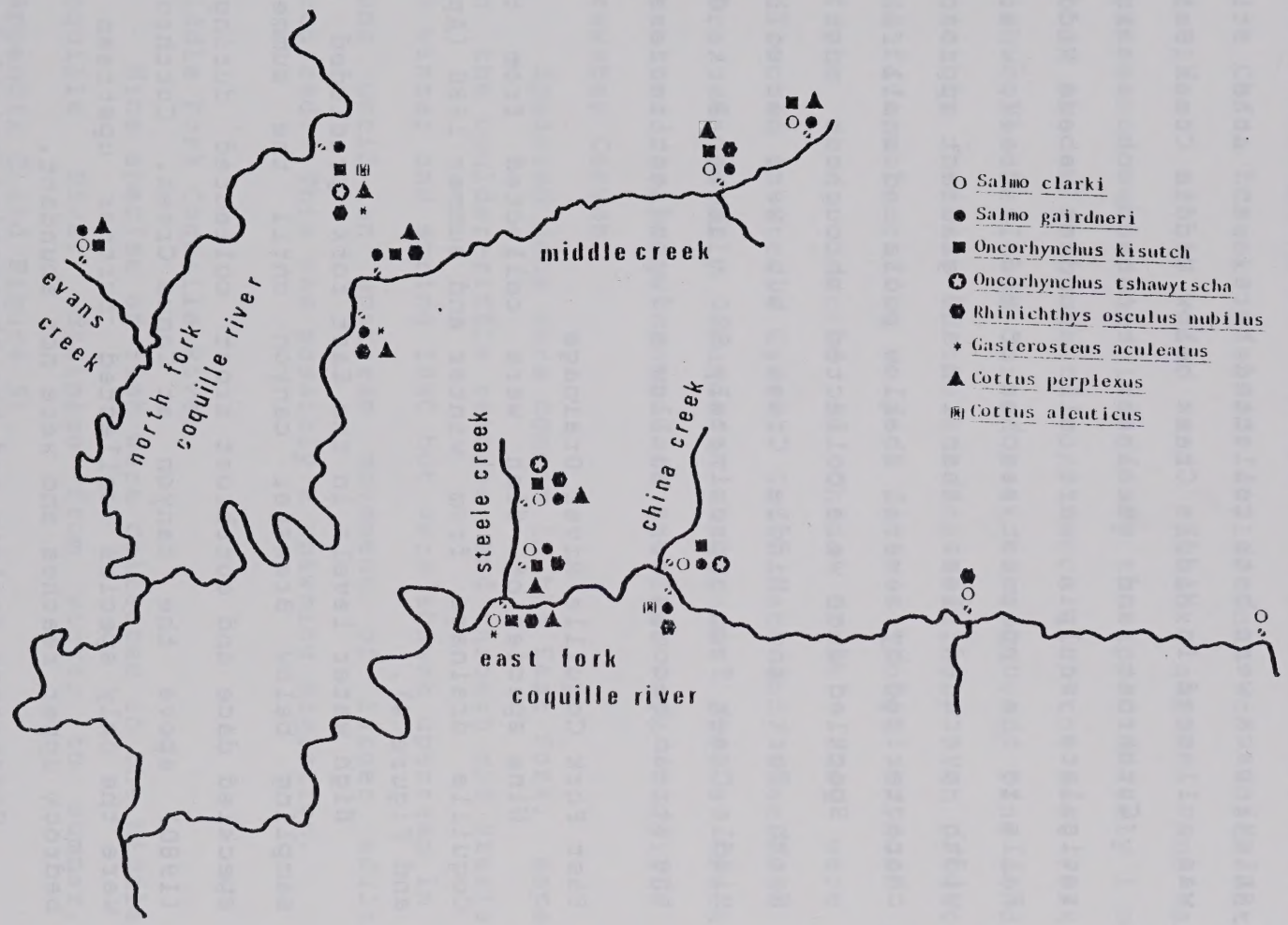


Figure 4. Map showing the relative locations of fish species collected from selected sites within the North Fork and East Fork Coquille drainages.

by extensive bedrock substrate and numerous gravel reaches. Coastrange sculpin (Cottus aleuticus) and threespine stickleback were both collected here, and the stickleback was collected in Middle Creek below Middle Creek Falls.

Cutthroat and steelhead trout, coho salmon and reticulate sculpin were all abundant above Middle Creek Falls to the uppermost reaches of Middle Creek, where stream width averaged less than 1 m and gradient approached 10%, characterized by several shallow pools and small falls.

Speckled dace were collected throughout most of the North Fork and Middle Creek, but were not collected in Middle Creek from approximately 500 m above Park Creek as the stream becomes more shallow and gradient increases.

East Fork Coquille River Drainage

Nine species of fish were collected from the East Coquille drainage from winter and summer 1980 (Appendix C and Figure 4).

High water levels in the East fork precluded adequate sampling below Brewster canyon until the summer, with speckled dace and cutthroat trout collected during winter (1980) above the canyon at Camus Creek. Cutthroat trout were the only species collected further upstream in the bedrock upper reaches and were not abundant.

Coastrange sculpin and the threespine stickleback were collected in the East Fork Coquille below Brewster Canyon and stickleback were collected in Steel Creek only to the

first riffle, which acted as a barrier to further upstream distribution.

China Creek yielded collections of cutthroat and steelhead trout, coho and chinook salmon. Non-salmonid upstream movement is hindered by the approximately 1 m drop from the culvert at its confluence with the East Fork. All fish collected from China Creek were in very fine condition, possibly because of the streams seemingly high productivity and favorable riffle to pool ratio. Though Chinook salmon (fry) were observed in China Creek, they were never collected in Steele Creek. Cutthroat and steelhead trout were especially abundant throughout Steele Creek with steelhead (rainbow) common in the East Fork Coquille below Brewster Canyon.

Speckled dace were common in the East Fork, especially in the boulder-riffle reaches, and through mid Steele Creek in winter and spring 1980 but were absent upstream in early June until an upstream movement of larger adult dace occurred. This was possibly a spawning migration.

Middle Fork Coquille River

Nine species of fish were collected in the Middle Fork Coquille River drainage from winter to summer, 1980 (Appendix C and Figure 5).

Cutthroat trout were not collected from either the Middle Fork or Big Creek, but may have been present in

Figure 5. Map showing relative locations of fish species collected in Big Creek and Middle Fork Coquille River.

smaller tributaries.

In the upper, mostly boulder bottomed, reaches of the Middle Fork Coquille at Bear Creek Recreation Site steelhead (rainbow) trout and speckled dace were collected during all collections. Several adult largescale suckers were also collected in early September.

The reticulate, prickly and coastrange sculpins were all collected in the riffle reaches of the Middle Fork near the Big Creek confluence, but only the reticulate sculpin was collected in the Big Creek.

Threespine stickleback were abundant in edgewater pools of the Middle Fork and isolated individuals were collected in low gradient pools in Big Creek up to Jones Creek.

Both chinook and coho salmon were collected from Big Creek but never in abundance.

Food Habits

The consumption in common by several species of fish by a wide variety of food organisms had led some investigators (Maitland 1965; Mason and Machidori 1976) to propose the possibility of interspecific competition for food and/or food as a limiting resource to some fish populations. Experiments on juvenile coho salmon during summer months revealed populations were limited by food availability (Mason 1974). Moyle (1976) noted the difficulty in demonstrating that food is limiting, inasmuch as feeding

strategies, total food availability and strategies of diet analysis influence the measure and interpretation of interspecific food habits.

Previous studies of the diets of sympatric stream fishes have found a high degree of diet overlap (Fraser 1969; Harley 1948; Li and Moyle 1976; Maitland 1965; Mason and Machidori 1976). In this study, the foods of fish from Vincent, Tioga and Middle Creeks clearly show overlapping of the food resource (Tables 4-8).

For all three creeks, Ephemeroptera and Diptera larva were numerically the most important components of the diet. Their significant contribution to the diet of stream fishes complies with the results from several previous studies. Breuser (1960) and Mundie (1969) demonstrated that Ephemeroptera and Diptera were the major benthic component of the coho diet. Idyll (1942) and Glova (1968) demonstrated their importance to the diet of steelhead and cutthroat trout, especially for fish up to 20 cm (Idyll 1942).

The diets of most stream sculpins of the genus Cottus have been demonstrated as similar (Bond 1963; Moyle 1976). Reticulate and riffle sculpin fed almost exclusively on Diptera and Ephemeroptera larva, most likely captured on the bottom. These two orders combined contributed 86.2% to the reticulate sculpin and 91.7% to the riffle sculpin diets. Sculpins are morphologically adapted as bottom dwellers,

with their large mouths allowing for efficient utilization of aquatic insects of varying sizes among the rock substrate.

Speckled dace consumed a greater variety of food items than the sculpins though they fed heavily on Ephemeroptera and Diptera larva (71.2%). Dace are active feeders among their preferred rock habitat whereas sculpins tend to be more stationary, patiently waiting in ambush for their prey (Li and Moyle 1976).

Although similarities in the diets were readily apparent, the differences were more distinct. Adult and terrestrial invertebrates contributed only 0.9% to the reticulate and riffle sculpin and speckled dace diets (benthic species) and 21.2% to the redside shiner, steelhead and cutthroat trout and coho salmon diets (opportunistic-drift feeders) (Table 8). Coho consumed a greater variety and number of terrestrially derived insects than did steehead. Peterson (1966) and Fraser (1969) attribute these two fishes feeding strategies to spatial segregation of a stratified nature, with coho associated with the surface and steelhead with the bottom. Chapman (1966), however, believes spatial segregation does not necessarily eliminate or minimize possible competition for food, inasmuch as two or more species utilizing a common food supply acts as a density legislative feature. (species A has some effect on species B). Brockson, Warren and Davis

(1968) suggested that the availability of drift foods was determined by the grazing intensity by sculpins on the stream benthos though Moyle (1977) questioned the validity of their findings due to lack of repetitions, the simplified experimental conditions resulting in problems applying their results to more complex natural systems.

Finally, conclusions from this analysis are obviously imcomplete due to the small number of samples and the general lack of information on the available standing crop of benthic invertebrates. Peterson (1966) believed the proportion of invertebrates in the drift was related to their proportion in the benthic standry crop.

In this instance, the fish of Vincent, Tioga and Middle creeks seem to be sharing a common food resource, especially the benthic component, with the possibility existing for local seasonal food limitations. More likely, with habitat segregation and behavioral diversity (feeding strategies, time of feeding, prey-switching) of fishes, direct competition for food would be restricted under normal conditions.

Relationship of Biological and Physical Variables

One of the objectives of this research is to define some relations between the physical habitat within the study streams and the fish populations (community) present. These relations are basic to stream fish ecology and can be

important in management because environmental disturbances (logging, road building, etc.) can possibly affect the physical nature of streams. Initial comprehension of stream fish and habitat relations therefore could be used to predict possible effects of environmental disturbances on fish populations.

Two potential weaknesses of this phase of the research were beyond our control. First, the study utilized sampling sites widely distributed over several river systems. Changes in fish populations, therefore, not only could be due to differences in the stream habitat, but also due to changes in the degree of specialization of the fishes of the community (i.e., species packing) and "differences in the temporal variability of the environment" (Horowitz 1978). Second, the number of observations was few relative to the number of variables. A large number of variables was measured to insure that the important physical features were included in the initial portions of the study. In future study, the number of variables could be reduced.

All references to significant correlations are from Table 11.

Coho Salmon

Coho numbers and biomass were both positively correlated with site length, maximum depth and percent sand, while biomass was also correlated with volume, surface area

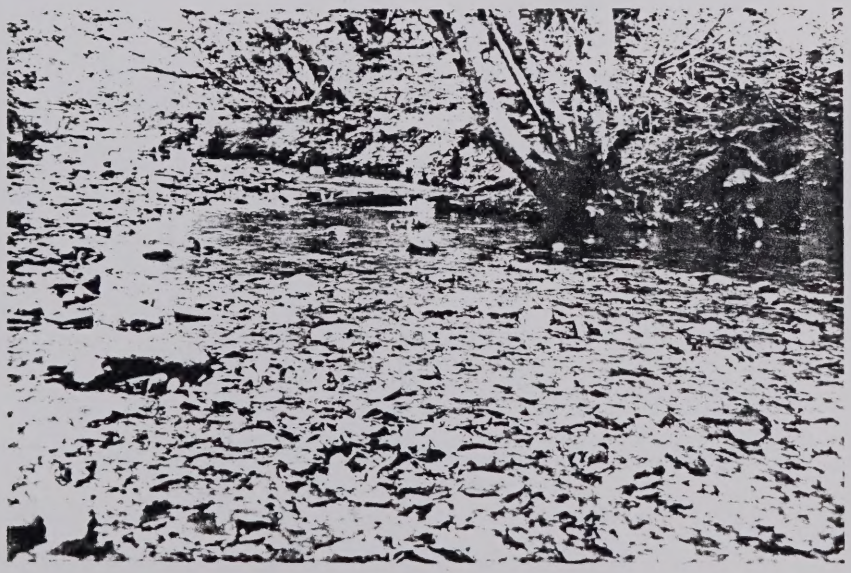
and percent pools. This would seem to indicate that coho were numerically responding to available habitat (site length) and preferred deeper, stable pool areas (with depositional sand) Figures 6a, 8a and 9a). Hartman (1965) observed pool occupancy by coho sympatric with steelhead while Glova and Mason (1976) demonstrated that during summer low flow coho abundance and biomass were highest in low velocity microhabitats (i.e., pools, glides). Ruggles (1966) and Mason (1966) noticed volitional residence of allopatric coho in pool-like environments in stream aquaria. Standing crop of juvenile coho was found directly related (r = .95) to pool volume (Nickelson and Reisenbuhler 1977; Nickelson and Hafele 1978).

Coho were abundant throughout the study streams during summer, 1980 wherever suitable alternating pool and riffle reaches occurred. Ruggles (1966) found that highest coho production occurred in reaches with approximately equal pool and riffle areas (Figure 9). The omission of coho from much of one long section of pool area (approximately one km) on Vincent Creek (Figure 7a) was due, I believe, to lack of riffles that could provide and transport invertebrate production.

As summer progressed and flows decreased, total biomass also decreased, possibly because of increased mortality or emigration brought on through spatial stress. Burns (1971) revealed that decreased living space resulted in increased

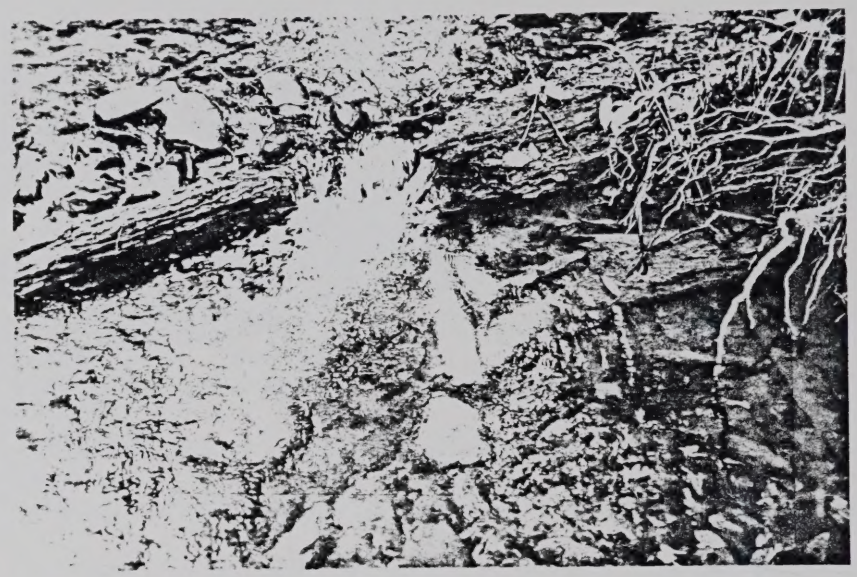
Figure 6. Study sites on Steele Creek within the East Fork Coquille River drainage.

a. View from north bank of downstream site (#2). Note the undercut bank in upper left corner that provided cover for steelhead and cutthroat trout and during late summer speckled dace.



b. Site #1, upstream and adjacent to site #2.

Figure 6. (continued) Examples of areas of instream cover available in upper Steele Creek site (#1).

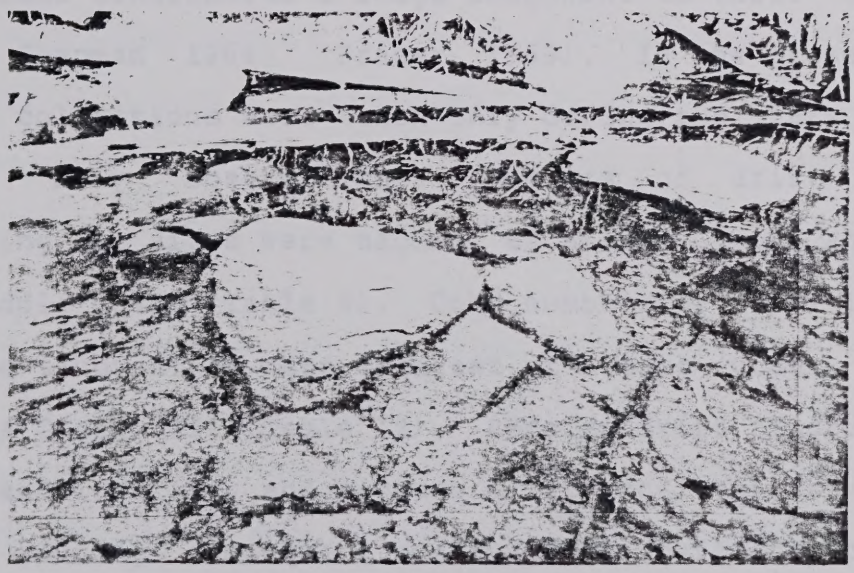


a. Small falls created good cover for steelhead and cutthroat trout.

b. Example of undercut bank which provided escape cover for steelhead and cutthroat trout and coho salmon.

Figure 7. Study site on Vincent Creek (#1).

a. View from east bank of study site. Note the lack of stream overstory or canopy.



b. View of instream boulders typical along west margin of the stream at this site.

fish mortality. Chapman (1962) found coho fry emigrants to be smaller than their cohorts remaining in the stream alluding to possible behavioral (agonostic) induced spatial constraints. Coho responded to decreased flows by emigrating from South Sisters Creek when fingerlings, particularly abundant in late June, were absent by late July when flow slowed to a trickle (less than 1 l/sec). Particularly low water conditions brought upon by drought or possibly a ravaged watershed could have a significant impact on coho behavior, and ultimately on survival, if remaining downstream rearing habitat becomes saturated with coho.

Mason (1966) concluded that coho densities were highest in areas of greater food availability and that drifting organisms contributed a large component to their diet (see also Chapman 1966; Fraser 1969). In the present study, drift collections were taken only during the late June to early July observations. Numbers of drift organisms entering the sites were highest at Steele Creek and lowest at Middle Creek (Table 9). Coho numbers or densities (g/m^2) at the study sites were greatest at Steele Creek (#2) and Middle Creek (#2) (Table 12). Because drift fluctuates over time and locality, and because drift collections were not taken during subsequent observations, definite conclusions concerning a possible relationship between coho density cannot be made.

Steelhead (rainbow) Trout

Trout numbers and biomass were not correlated with identical variables. Negative correlation of numbers and Julian day can be attributed to decreasing populations of trout as summer progressed. Maximum temperature and percent bedrock were also positively correlated with trout numbers and biomass. The latter two measures were greatest when water temperatures were highest from June to August. Bare sandstone bedrock, the predominant substrate in the study streams, is indicative of a noticeable current that prevents sediment deposition. Studies by Everest and Chapman (1972), Hartman (1965) and Saunders and Smith (1962) have shown Age 0 steelhead usually restricted to the shallower riffle reaches, most likely because of competitive exclusion by larger steelhead and other stream salmonids (coho and chinook salmon, cutthroat trout). Hartman (1965) believed behaviorial interaction resulted in steelhead being restricted to riffle reaches when they were sympatric with coho.

Another characteristic of bedrock as good rearing habitat is its structural irregularities (breaks and ledges), which provide for suitable cover (Figure 8b). Age 0 steelhead were commonly observed utilizing these habitats in riffles in most streams, especially during early summer.

Biomass was positively correlated with percent instream cover indicating that as steelhead grow larger they sought

of the smaller tributaries and headwaters of streams (Lowry 1965), especially when occuring naturally with steelhead (rainbow) (Moyle 1976). If this is the case, cutthroat would seem more tolerant of environmental extremes characteristic of these waters. These waters are characteristically of higher elevation, heavily canopied, narrow and shallow, and have low flow (Figure 10). Studies by Glova (1978) on resource partitioning between coho and cutthroat suggested that cutthroat illustrated greater flexibility of behavior, possibly due to subordination. Glova thought that behavioral flexibility may counteract "heterogeneity and instability of stream environments" often found in 'typical' cutthroat habitat.

Large cutthroat (20 to 29 cm) were observed and collected throughout the lower and mid-reaches of streams usually as solitary individuals and always associated near instream (escape) cover. Smaller cutthroat to 20 cm were often aggregated (though not in schools) in association with large areas of cover, exemplified by fallen logs with depositional debris and by beaver dams (Figure 6 b-d). Lowry (1965) found that cutthroat fry in three Oregon coastal streams inhabited shallow, small tributaries of slight velocity then dropped downstream gradually as they grew. Age III or older cutthroat usually occupied areas of heavy cover such as cutbanks or close to the edge of the current in deeper water.

and were observed associated with undercut banks, fallen logs, boulders, deep ledges, etc. (Figure 6 b-d). Saunders and Smith (1962) found that as rainbow grew larger they sought out "flat" areas with "hiding" places.

Steelhead were usually not observed in slow pools (an exception being intermittent South Sisters Creek) but were collected in pre- and post-riffle reaches which were areas of increasing current and decreasing depth. These reaches also serve as transport areas for the invertebrate production (i.e., benthic drift, terrestrial input) demonstrated as important to the diet of steelhead (Fraser 1969; Peterson 1966).

Cutthroat Trout

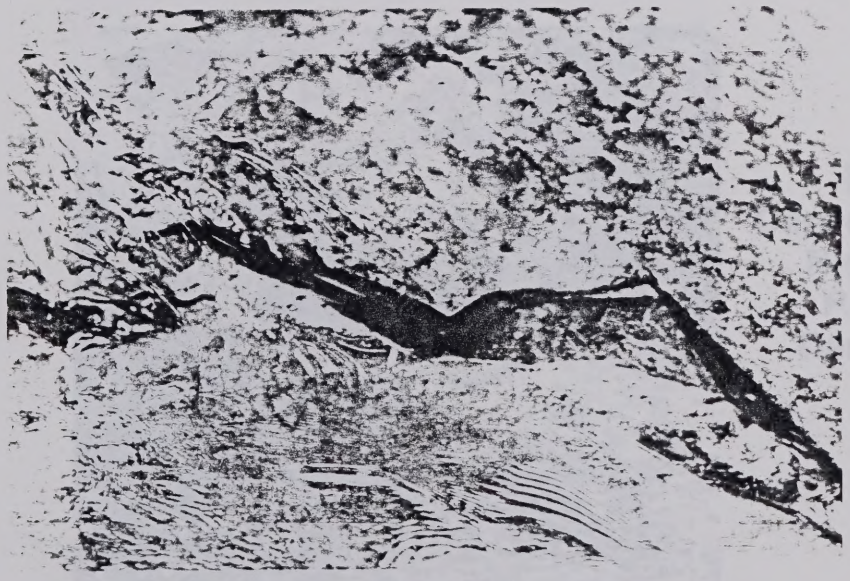
Cutthroat were not noticeably abundant at the study sites except for juvenile fish in South Sisters Creek. There, as the creek became intermittent in late August, only steelhead and cutthroat were collected in small shallow pools. Through September, cutthroat numbers stayed relatively stable with very few steelhead remaining by late September when D.O. was measured a low 4 mg/l.

In this analysis, cutthroat numbers (and biomass) were found correlated positively with elevation, canopy and shade and negatively correlated with average and maximum width, volume, and surface area, flow and minimum temperature.

Cutthroat are normally thought more common inhabitants

Figure 8. Study site on lower Vincent Creek (#2).

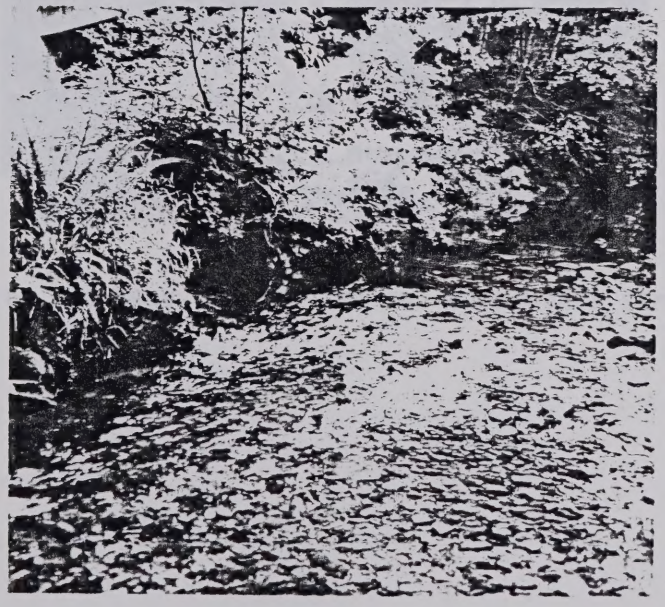
a. Upstream view of study site. Note the extensive sandstone bedrock typical of this drainage.



b. View of one of the common ledges found in bedrock. Ledges were used extensively by young steelhead during early summer.

Figure 9. Study sites on West Fork Smith River.

a. Site #1, representative of pool habitat found in upper West Fork Smith River.



b. Site #2, downstream and adjacent to site #1. Typifies riffle habitat found in upper West Fork Smith River.

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Figure 10. Study site at South Sisters Creek. Upstream view was taken in late June. During August this site became an isolated pool as the creek became intermittent.

a. Note the heavy canopy typical along this stream.

This seemed to indicate preference for wide and deep (larger) streams with adequate large cover. The high correlation with average and maximum depth and volume is most likely an artifact of the abundance of sculpins at Vincent Creek site (#1). Abundant cover in the form of mixed substrate and boulder was present at that site (Table 3). These sculpins actually were widespread and observed in a wide variety of habitats. They were almost never associated with bare bedrock unless suitable rocks or debris patches provided adequate background for their cryptic coloration. The preference of Cottus for rocky substrates can be attributed to several factors including cover (protection) (Bond 1963; Mason and Machidori 1976) and food availability (Bond 1963; Brocksen et al. 1968; Mason and Machidori 1976). Mixed substrate provides concealment, either directly or cryptically, from predation by other fishes and is important in the production of, and as preferred habitat for, many of the benthic aquatic insects consumed by sculpins (Cummins 1966; Hynes 1970; Waters 1969).

Reticulate sculpins were collected in both fast shallow riffles and from still pools (Vincent Creek, #1) (Figure 7). Overall, reticulate sculpins seem adaptable to a wide range of environmental conditions and fluctuations. Finger (1979) termed the reticulate sculpin a 'generalist' inhabiting a wide variety of habitats when found together with two other

Of four species of sculpins of genus Cottus collected during this study, only two, the reticulate and riffle sculpin, were found at the study sites. The prickly and coastrange sculpins were limited to the main river systems, not contributing to the structure of the stream fish communities of salmonid rearing areas in the study streams.

The reticulate sculpin is the most widely distributed of the several species of Cottus that inhabit the coastal streams of western Oregon (Bond 1963). Reticulate and riffle sculpins exhibit similar morphology and feeding strategies, with habitat selection the major ecological difference between the species.

During this study, the two species of sculpins were associated with the stream bottom or instream debris (i.e., rubble, boulders, wood, etc.) except for several individuals in Vincent Creek (site #1) that were observed feeding on speckled dace fry in the water column.

Reticulate Sculpin

Reticulate sculpin were collected at all study sites except the South Sisters site. Both numbers and total biomass decreased as summer progressed though sculpin fry (less than 30 mm) were especially abundant but not included in this analysis.

Reticulate sculpin numbers correlated positively with average and maximum depth, volume, flow and percent boulder.

Cottus species.

Riffle sculpin

Riffle sculpins were collected only in the Smith River and South Coos River drainages. They illustrated disjunct in-stream distribution, often absent from seemingly suitable habitat but then present in adjacent reaches. Not unlike the reticulate sculpin, riffle sculpins are found in a wide variety of habitats, but seem to prefer cool water and gravel bottoms, avoiding the swiftest riffle areas (Moyle 1976). The distribution of riffle sculpins in Oregon and Washington is remarkably patchy (Bond 1973).

Riffle sculpin numbers and biomass were correlated positively with average and maximum width, volume, surface area and percent boulder, much like the reticulate sculpin, in indicating greater occurrence in the wider reaches with large instream cover. They were collected from many diverse habitats including the shallow slow pool reaches of upper South Sisters Creek, disappearing, as flows decreased. In Vincent Creek (site#1) they were found in deep pool sections of negligible flow among boulders.

The riffle sculpin, again not unlike the reticulate sculpin, was dependent upon suitable instream cover, utilizing available patches of mixed substrate on bare bedrock, but seemed to prefer cobble size rocks or larger. They were rarely collected from fast riffles (except for a

few fish greater than 8 cm). They were present in South Sisters Creek until the stream became intermittent, indicating avoidance of decreasing flows and corresponding decreased D.O.. Bond (1963) found that sculpins avoided areas of D.O. less than 4 mg/l.

When found together in reaches with the reticulate sculpin, riffle sculpins would invariably be less common in the riffle reaches and more associated with larger cover or substrate. In Vincent Creek at site (#) 1, with negligible flow, both sculpins were evenly distributed among the boulder areas, with reticulate sculpin more common on the remaining mixed substrate.

Speckled Dace

Speckled dace numbers and biomass were correlated positively with instream cover and negatively correlated with elevation. In addition, dace numbers correlated positively with maximum depth. Dace were not collected at the two upper West Fork Smith, and South Sisters and the upper Middle Creek sites. These were all elevated upstream sites, South Sisters becoming intermittent and West Fork Smith and Middle Creek sites mostly shallow with few pool areas and little instream cover. In coastal streams upstream reaches are usually characterized by moderate to high gradient, usually deemed unsuitable as speckled dace habitat (Gard and Flittner 1974).

Speckled dace inhabit wide variety of habitats, but are usually associated with riffles and pools with current (Moyle 1976). Dace were always observed and collected associated with instream cover. They were collected among boulders in the fastest riffles in the main rivers and larger streams and occurred in upstream pools of moderate current, again associated with cover, usually boulders or undercut banks (Figure 6). The lack of adequate current over the extensive boulder area at Vincent Creek site (#) 1 is assumed to account for the low numbers of dace captured.

Upstream distribution never seemed to be hindered due to small falls and other obstructions, yet dace seemed responsive to certain environmental cues, possibly including increasing gradient and shallowing water with its decreasing instream cover. Studies on the distribution of fishes in Sagehen Creek in California revealed that dace were absent from high gradient reaches, areas of low water temperatures and unfavorable pool/riffle ratios, with limited instream cover (Gard and Flittner 1974).

Longnose Dace

Longnose dace were collected only from the South Coos drainage and were found in this phase of the study only at Tioga Creek site (#) 1.

Longnose dace are thought always to inhabit areas of moderate to swift current and gravel boulder substrates (Gee

and Northcote 1963; Gibbons and Gee 1972). These two studies indicated that the longnose dace showed a preference for velocities greater than 45 cm/sec, although they were captured also at lower velocities especially during summer low flow. Although I found longnose dace to be most abundant in South Coos River and lower Tioga Creek where swift riffles were common, I found them at Tioga Creek site (#) 1 where the current was only 10 cm/sec.

Redside Shiner

Redside shiners were collected only in the Smith River and South Coos River drainages, and in this analysis were found only at the lower Vincent Creek site (Table 1 and Figure 8). Mostly, their instream distribution will be analyzed from observational and collection data.

Shiner numbers and biomass were correlated with the same variables. Positive correlations were found with maximum temperature and percent bedrock, with negative correlations found with percents mixed substate, coarse gravel, and small gravel. Shiners were most abundant in the warmer bedrock reaches of streams and were always observed in pools. Schools of shiners were observed in upstream migration in Vincent, South Sisters and West Fork Smith River in late June, easily negotiating riffle reaches elevating 1 m. They were moving into the cooler tributaries possibly to spawn and/or avoid the elevated temperatures of

the Smith River. A study over several years by Lindsey and Northcote (1963) demonstrated that dace spawn during the summer months. They also found an association between shiner movement and maximum stream temperature.

Shiners were collected mainly from pools of depth greater than 0.3 m. I suggest that their furthest upstream distribution is limited by decreased availability of suitable pools, decreasing flow and increasing gradient. Similar to the speckled dace, redside shiner in Sagehen Creek were collected in areas of low gradient, elevated temperatures and reaches with adequate pool/riffle ratios (Gard and Flittner 1974). Shiners were collected upstream to 16.5 km in West Fork Smith without observable obstructions hindering further upstream movement. Farther upstream, gradient increases rapidly (to 47 m/km), pool depth decreases and cooler water temperature prevail, most likely creating unfavorable redside shiner habitat.

Relationship among Biological Variables

High correlations between numbers of fish and total biomass for all species were found and should be expected, though few other interspecific relationships were noted through correlation analysis.

Coho biomass levels and numbers of speckled dace were significantly correlated inasmuch as both measures peaked in early August then declined through September. This type of

pattern was found also between steelhead trout numbers and reticulate sculpin biomass. Analysis of the few remaining significant relationships were unexplained because of the small numbers of fish and observations involved.

Total fish biomass per unit surface area greatly varied over time at each site and ranged from 0.24 to 15.52 g/m^2 (Tables 12 and 13). Average levels of 1.5 - 9.0 g/m^2 were similar to those reported by Glova and Mason (1977) at 2-9 g/m^2 and Mason and Machidori (1976) at 7-10 g/m^2 for sympatric fishes including salmonids and sculpins.

Table 12. Biomass per unit surface are of fishes collected at study sites on South Sisters Creek, West Fork Smith River and Vincent Creek. Units are g/m^2.

Location	Date	Coho Salmon	Steelhead Trout	Cuttthroat Trout	Reticulate Sculpin	Riffle Sculpin	Speckled Dace	Redside Shiner
South Sisters Creek	17 June	0.78	1.06	1.26	--	0.97	--	--
	3 Aug	0.00	4.00	3.95	--	1.23	--	--
	4 Sept	0.00	7.71	7.81	--	0.00	--	--
	21 Sept	0.00	1.07	3.80	--	0.00	--	--
West Fork Smith (#1)	23 June	1.42	0.18	0.00	2.27	0.59	--	--
	4 Aug	1.66	0.32	0.05	0.57	0.40	--	--
	4 Sept	0.05	0.15	0.00	0.28	0.65	--	--
	21 Sept	2.91	0.70	0.00	0.53	0.16	--	--
West Fork Smith (#2)	24 June	0.00	1.57	1.01	1.78	0.25	--	--
	4 Aug	0.22	0.65	0.10	1.11	0.21	--	--
	21 Sept	0.15	0.47	0.12	1.30	0.17	--	--
Vincent Creek (#1)	18 June	0.05	0.01	--	1.18	0.15	0.26	--
	5 Aug	0.00	0.04	--	0.89	0.96	0.30	--
	5 Sept	0.00	0.09	--	0.63	0.78	0.25	--
Vincent Creek (#2)	25 June	0.82	0.99	0.00	1.55	--	0.36	0.60
	5 Aug	0.66	1.48	0.00	0.80	--	0.28	1.54
	5 Sept	0.08	0.28	0.00	0.37	--	0.18	0.41
	21 Sept	0.10	0.54	0.12	0.68	--	0.10	0.56

Table 12. (Contined) Biomass per unit surface area of fishes collected at study sites on Steele, Middle, and Tioga Creeks. Units are g/m^2.

Location	Date	Coho Salmon	Steelhead Trout	Cutthroat Trout	Reticulate Sculpin	Riffle Sculpin	Speckled Dace	Longnose Dace
Steele Creek (#1)	2 July	1.11	0.28	0.00	0.72	--	0.00	--
	8 Aug	1.26	0.53	0.81	0.27	--	0.18	--
	2 Sept	0.89	0.30	0.59	0.41	--	0.67	--
	19 Sept	1.75	0.39	2.05	0.16	--	0.38	--
Steele Creek (#2)	3 July	2.62	1.16	1.44	0.78	--	0.00	--
	8 Aug	2.36	1.02	1.16	0.72	--	4.52	--
	2 Sept	2.25	1.18	0.81	0.76	--	2.31	--
	19 Sept	1.55	0.86	4.01	0.19	--	1.09	--
Middle Creek (#1)	8 July	0.32	0.36	0.00	0.87	--	--	--
	7 Aug	1.11	0.44	0.40	0.97	--	--	--
	3 Sept	0.40	0.08	0.00	0.29	--	--	--
	20 Sept	0.09	0.00	0.00	0.15	--	--	--
Middle Creek (#2)	9 July	2.27	0.11	0.00	0.64	--	0.12	--
	7 Aug	2.70	0.05	0.12	0.30	--	0.17	--
	3 Sept	2.14	0.21	0.10	0.18	--	0.10	--
	20 Sept	2.20	0.04	0.00	0.27	--	0.04	--
Tioga Creek (#1)	10 July	0.11	0.04	--	0.19	0.10	0.15	0.23
	6 Aug	0.10	0.26	--	0.25	0.00	0.14	0.15
Tioga Creek (#2)	10 July	0.69	0.05	--	0.12	0.33	0.24	--
	6 Aug	0.83	0.10	--	0.16	0.88	0.19	--
	3 Sept	0.71	0.06	--	0.07	0.11	0.07	--
	20 Sept	0.17	0.12	--	0.02	0.16	0.05	--

Table 13. Biomass per surface area of salmonid and non-salmonid fishes at the study sites on all observation days. Units are g/m^2. Site notation (#1) refers always to upstream site.

Location	Date	Salmonid Fishes	Non-Salmonid Fishes	Total Biomass
South Sisters Creek	17 June	3.11	0.97	4.08
	3 Aug.	7.95	1.23	9.18
	4 Sept.	15.52	0.00	15.52
	21 Sept.	4.87	0.00	4.87
West Fork Smith (#1)	24 June	1.60	2.86	4.46
	4 Aug.	2.03	0.97	3.00
	4 Sept.	0.20	0.93	1.13
	21 Sept.	3.61	0.69	4.30
West Fork Smith (#2)	24 June	2.58	2.03	4.61
	4 Aug.	0.97	1.32	2.29
	21 Sept.	0.74	1.47	2.21
Vincent Creek (#1)	18 June	0.06	1.59	1.65
	5 Aug.	0.04	2.15	2.19
	5 Sept.	0.09	1.66	1.75
Vincent Creek (#2)	25 June	1.81	2.51	4.32
	5 Aug.	2.14	2.62	4.76
	5 Sept.	0.36	0.96	1.32
	21 Sept.	0.76	1.54	2.30

Table 3. (Continued)

Location	Date	Salmonid Fishes	Non-Salmonid Fishes	Total Biomass
Steele Creek	2 July	1.39	0.72	2.11
(#1)	8 Aug.	2.60	0.45	3.05
	2 Sept.	1.78	1.08	2.86
	19 Sept.	4.19	0.54	4.73
Steele Creek	3 July	5.22	0.78	6.00
(#2)	8 Aug.	4.54	5.24	9.78
	2 Sept.	4.24	3.07	7.31
	19 Sept.	6.42	1.28	7.70
Middle Creek	8 July	0.68	0.87	1.55
(#1)	7 Aug.	1.55	0.97	2.52
	3 Sept.	0.48	0.29	0.77
	20 Sept.	0.09	0.15	0.24
Middle Creek	9 July	2.38	0.76	3.14
(#2)	7 Aug.	2.87	0.47	3.34
	3 Sept.	2.45	0.28	2.73
	20 Sept.	2.24	0.31	2.55
Tioga Creek	10 July	0.15	0.67	0.82
(#1)	6 Aug.	0.46	0.54	1.00
Tioga Creek	10 July	0.74	0.69	1.43
(#2)	6 Aug.	0.93	1.23	2.16
	3 Sept.	0.77	0.25	1.02
	20 Sept.	0.29	0.23	0.52

SUMMARY AND CONCLUSIONS

Although the duration of this study was short, the information obtained concerning distribution, ecology, and behavior of the fishes of the study streams is compatible with published accounts and with unpublished data available at Oregon State University. Additional study could modify and refine these findings, and add greater confidence in their validity. A summary of results and conclusions follows.

1. The study sites were characterized by good populations of juvenile coho salmon and steelhead trout, demonstrating the importance of these typical small steams as rearing areas for anadromous species. Chinook salmon were not present at most sites, and populations of cutthroat trout were generally small.

2. None of the study sites held all the native, non-salmonid species available in its particular watershed. Mostly those species typical of small streams were present. The typical association included sculpins, lampreys, and salmonids. Umpqua dace, Umpqua squawfish, bigscale sucker, threespine stickleback and prickly sculpin were taken only below the selected study sites. No introduced species were collected at any study site.

3. Diversity of habitat within the various study streams was attributable not only to geological and climatic factors, but disturbance by fires, erosion, activity of

beavers, and logging. In some instances effects of disturbances were beneficial. For instance, beaver ponds created excellent rearing pools for coho. Mostly, disturbance of natural cover and the soil surface had led to such deleterious effects as siltation.

4. Excluding the lampreys, all species of fish in the study areas depended upon insects for the major portion of their food. There was considerable overlap in the diets. Ephemeroptera and Diptera larvae were the major components of the diets of all species present. Coho salmon, in contrast to the others, took a moderate amount of food of terrestrial origin, probably capturing much of it at the surface. Coho salmon were most versatile in acceptance of foods, taking 19 of the separate categories tabulated; steelhead, shiners, and speckled dace took 15, 14, and 12 categories respectively. The reticulate sculpin, riffle sculpin and cutthroat trout were more restricted in diet, taking 7, 4 and 5 food types respectively. Because there was no indication that insects were a scarce resource, overlap in diet is not considered to indicate significant competition.

5. Distribution of fishes at the study sites appears to be mainly a function of habitat selection, but without in-stream behavioral studies no evaluation can be made. Lamphrey ammocoetes are burrowers, and were probably not affected by the other species. The reticulate and riffle

sculpins, both of which are benthic and cryptic, and select the same kind of cover, no doubt interact in the gravelly riffles that appear to be the preferred habitat. The speckled dace, a benthic species less cryptic than the sculpins, was common throughout large streams, almost always in the vicinity of adequate cover. They were excluded from upstream areas of increased gradient.

Steelhead and cutthroat trout were found most often in association with instream cover, although they were less cryptic than the sculpins or dace. Steelhead fingerlings were usually associated with shallow riffle reaches of moderate current. The larger individuals were found near instream cover. Young of the year cutthroat trout were found mainly in small, headwater reaches. Yearlings and older individuals generally were in solitary residence in midstream and downstream reaches, and were associated with cover.

Coho salmon were found in loose schools throughout pools in areas where short pools alternated with riffles. Exceptionally long pools generally held coho only at the upper end. Coho shared the warmer, wider pools in the Smith River and South Coos River drainages with the redside shiner, although the two species segregate themselves. Redside shiners were excluded from upstream areas with increased gradient and shallow pools.

6. Limitations on populations of salmonid fishes in

the study streams are probably associated with lack of adequate summer flow, lack of instream cover, siltation of gravel and rubble bottoms and departure from an approximate 1:1 pool to riffle ratio.

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APPENDICES

Appendix A

Coastal river drainages containing study streams investigated during this study. Streams are located on lands managed by the Bureau of Land Management; Coos Bay District.

Umpqua River Drainage

- Smith River,main stem
  - Vincent Creek
  - West Fork Smith River
  - South Sisters Creek

Coos River Drainage

- South Coos River
  - Tioga Creek

Coquille River Drainage

- North Fork Coquille River
  - Middle Creek
- East Fork Coquille River
  - Steele Creek
  - China Creek
- Middle Fork Coquille River
  - Big Creek

Appendix B

List of native freshwater and anadromous fishes known, from this study and the literature,to occur in the Umpqua, Coos and Coquille drainages.

Fish Species		River Drainages		
Common Name	Scientific Name	Umpqua	Coos	Coquille
Pacific Brook Lamprey	Lampetra pacifica	X	X	X
Western Brook Lamprey	Lampetra richardsoni	X (?)		
Pacific Lamprey	Lampetra tridentata	X	X	X
Chum Salmon [1]	Oncorhynchus keta	X	X	X
Coho Salmon	Oncorhynchus kisutch	X	X	X
Chinook Salmon	Oncorhynchus tshawytscha	X	X	X
Cutthroat Trout	Salmo clarki clarki	X	X	X
Steelhead (Rainbow) Trout	Salmo gairdneri	X	X	X
Oregon Chub	Hybopsis crameri	X		
Umpqua Squawfish	Ptychocheilus umpquae	X		
Longnose Dace	Rhinichthys cataractae		X	
Umpqua Dace	Rhinichthys evermanni	X		
Speckled Dace	Rhinichthys osculus	X	X	X
Redside Shiner	Richardsonius b. balteatus	X	X	
Largescale Sucker	Catostomus macrocheilus	X	X	X

Fish Species		River Drainages		
Common Name	Scientific Name	Umpqua	Coos	Coquille
Three-spined stickleback	Gasterosteus a. microcephalus	X	X	X
Coastrange Sculpin[1]	Cottus aleuticus	X	X	X
Reticulate Sculpin	Cottus perplexus	X	X	X
Prickly Sculpin	Cottus asper	X	X	X
Riffle Sculpin	Cottus gulosus	X	X[2]	X

1- Not found upstream in main rivers or collected from tributaries.

2- Not previously collected from this drainage.

Appendix C

Location of the 11 established study sites.

Smith River Drainage

South Sisters Creek
located 2.5 km east of Bum Creek road. T20S/R8W/Sec. 13

West Fork Smith River
Two adjacent sites located 18.2 km north of Smith River road at junction of Upper West Fork road. T19S/R8W/Sec. 30

Vincent Creek
Upstream site located 6.4 km south of Smith River road. T21S/R9W/Sec. 10
Downstream site located 1.7 km south of Smith River road adjacent to gauging station. T20S/R9W/Sec. 33

South Coos River Drainage

Tioga Creek
Two adjacent sites located 5.8 km south of Shotgun Creek influence or 7.4 km north of Summit of Middle Creek access road. T26S/R9W/Sec. 31

North Fork Coquille River Drainage

Middle Creek
Two sites (separated by approx. 50 m) located 0.32 km north of Park Creek. T27S/R10W/Sec. 4

East Fork Coquille River Drainage

Steele Creek
Two adjacent sites located 2.0 km north along Steele Creek road. T28S/R11W/Sec. 1

Appendix D

Fish species collected within five river drainages from Fall 1979 through Summer 1980.

	Smith River	South Coos River	North Fork Coquille	East Fork Coquille	Middle Fork Coquille
Lampetra tridentata	X	X	X	X	–
Salmo clarki	X	X	X	X	–
Salmo gairdneri	X	X	X	X	X
Oncorhynchus kisutch	X	X	X	X	X
Oncorhynchus tshawytscha	--	X	X	X	X
Richardsonius balteaus	X	X	–	–	–
Rhinichthys osculus	X	X	X	X	X
Rhinichthys evermanni	X[1]	–	–	–	–
Rhinichthys cataractae	–	X	–	–	–
Ptychocheilus umpquae	X[1]	–	–	–	–
Catostomas macrocheilus	X[1]	X[1]	–	–	X
Gasterosteus aculeatus	–	X[1]	X	X	X
Cottus perplexus	X	X	X	X	X
Cottus gulosus	X	X	–	–	–
Cottus asper	X[1]	–	–	–	X[1]
Cottus aleuticus	–	–	X[1]	X[1]	X[1]

[1]Collected only in the main river systems and apparently excluded from the study streams and tributaries.